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THE EASTERN ONTARIO SUBSIDIARY AGREEMENT

DRAINAGE PROGRAM . IMPACTS ON THE LAND RESOURCE

AN INITIAL EVALUATION

WORKING PAPER No. 40

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THE EASTERN ONTARIO SUBSIDIARY AGREEMENT DRAINAGE PROGRAM: IMPACTS ON THE LAND RESOURCE AN INITIAL EVALUATION

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March 1985

A report of the Land-Use Policy and Research Branch program which analyses the impact of federal activities on the use and maintenance of Canada's land resource.

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L'impact sur les terres du programme de sortie de drainage municipale établi dans le cadre de l'entente auxiliaire Canada-Ontario pour l'est de l'Ontario: une première évaluation

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PREFACE

This working paper provides a preliminary analysis of the effectiveness of the Eastern Ontario Subsidiary Agreement Municipal Outlet Drainage Program as it relates to the land resource. It is one of a series of reports by the Lands Directorate which analyse the effects of federal activities on the use and maintenance of Canada's land resource. This series of studies is conducted in support of the Federal Policy on Land Use (Government of Canada, 1981). The goal of the Policy is to ensure that federal policies and programs as well as the management of federal land contribute to the wise use of Canada's land resource. The Policy provides a series of guidelines which should be applied in the planning and administration of all federal government programs with respect to the land resource. Implementation of the Policy is coordinated by the Interdepartmental Committee on Land.

The findings, conclusions and recommendations in this and other reports on federal program impacts are intended to accomplish two important goals. First, the information and recommendations will be of use to federal program managers for the particular program as well as to those who manage other similar types of program, making them aware of the actual and potential consequences of their program for the land resource and alerting them to recommended solutions. Second, federal policy-makers responsible for broad government actions will be informed of the land-use effects and recommended alternatives for certain types of federal programs.

RÉSUMÉ

Le rapport présente une évaluation préliminaire du programme de sortie de drainage municipale en vertu de l'entente auxiliaire pour l'est de l'Ontario relativement à la ressource terre. L'analyse du programme de sortie de drainage municipale adopte plusieurs perspectives et se base sur un échantillon de 64 canalisations de drainage.

Les principales conclusions tirées des préoccupations relatives à la ressource terre sont les suivantes:

(1) La sélection des terres destinées au réseau de canalisation de drainage n'a pas été efficace;

(2) La perte des terres humides résultant du programme de sortie de drainage municipale est susceptible d'être importante;

(3) Dans le cadre de ce programme, aucun mécanisme n'existe pour évaluer l'effet cumulatif de la perte de terres humides;

(4) En rétrospective, il semble que plusieurs aspects du programme de sortie de drainage municipale n'auraient pas satisfaits les politiques et principes de la politique fédérale sur l'utilisation des terres. L'approbation pour l'installation de drains par exemple, semble avoir été prise sans tenir compte du potentiel agricole des terres;

(5) Se basant sur une approximation relativement généreuse des bénéfices incombant à l'agriculture ainsi qu'une estimation conservatrice des coûts, on peut suggérer qu'un nombre important de canalisation de drainage subventionnées en vertu du programme, n'engendreront pas de bénéfices futurs qui soient égales à leurs coûts.

En lumière des problèmes identifiés, cette étude propose au gouvernement fédéral une série de recommandations visant à assurer que les futurs programmes de drainage impliquant une contribution fédérale n'approuvent que les canalisations de drainage localisées sur les terres appropriées au drainage tout en tenant compte des effets adverses sur l'environnement.

EXECUTIVE SUMMARY

In 1979 the federal government, under the authority of the Canada-Ontario General Development Agreement, entered into a five-year agreement - the Eastern Ontario Subsidy Agreement (EOSA), which in part provided for the support of the construction of municipal outlet drainage through the Municipal Outlet Drainage Program. Approximately $11 million were made available to the program. A total of 252 municipal drains in eastern Ontario were subsidized by these funds.

For those outlet drainage schemes which met the requirements of the program, a grant covering two-thirds of the cost of the agricultural component of the drains was provided. Provision of this grant was apportioned equally from the federal and provincial government. The remainder was covered by the land owners within the drainage basin of each drain.

To be eligible a drain had to both be in one of the 14 counties and regional municipalities in eastern Ontario, and meet the requirements of the Ontario Drainage Act. Under this Act, drains are usually initiated by petition (i.e. by the majority of owners, or the owners of 60 percent of the area within the drainage basin). Applications had to be forwarded to the Drainage Petition Review Committee (DPRC) for funding approval under the Municipal Outlet Drainage Program.

This report provides a preliminary analysis of the effectiveness of the Municipal Outlet Drainage Program as it relates to the land resource. Based on an examination of a sample of 64 drains, this study analyses the program from four specific perspectives.

First, the program is evaluated through its ability to target those lands which are most likely to receive benefit from the drainage. Eastern Ontario possesses a significant proportion of wet soils, but not all have a high capability for agriculture. Generally, it appears that the proportion of high capability wet soils in the basins of the sample drains are not significantly different from the overall proportion of such soils in eastern Ontario. That, with the observation that there exists a wide range of percentages of wet soils in the drain basins, suggests a lack of effective targeting of appropriate lands for drainage. Indeed, the drains constructed under the program received funding on a first come basis without consideration for the characteristics of the land.

Second, since wetlands are an important feature of the natural environment and are affected by drainage, the impact of the program on these areas was appraised. By extrapolating the results of the 64 drains analysed in this study to the entire program, it was estimated that about 16,000 ha or about 10 percent of the extant wetlands in the area of active drainage in eastern

Ontario could be directly or indirectly affected by the program. As a result, considering this was but a five-year program and there is no mechanism to evaluate the cumulative effect of wetland losses on the wildlife, hydrology or water quality of the region, there is reason to suggest that the loss may be of significance. Further, it raises the more fundamental question of why an evaluation mechanism was not, in fact, in place to assess cumulative effects.

Third, the conformance of the program to the Federal Policy on Land Use was assessed. There were no effective mechanisms in the program to make use of a complete, comprehensive and widely understood knowledge of the land resource as it relates to soils and agricultural capability. Drain approvals were made irrespective of the land resource capability. No effective means was available for adequate assessment of the environmental impacts of many of the program's activities due to the high costs of assessment and the limited resources of the DPRC. In retrospect, many aspects of the drainage program would not have satisfied the policies and guidelines of the Federal Policy on Land Use.

Finally, a consideration of a benefit-cost analysis of the agricultural consequences of the drainage schemes was performed. Given a reasonably generous evaluation of the benefits likely to accrue to agriculture from drainage and a conservative consideration of the costs, it was found that a significant number of the drains subsidized by the program are unlikely to generate future benefits equal to the costs of the drains. Indeed, it appears likely that this would be the case for a majority of the drains. Given the level of the subsidization, other costs borne by government, and the provision of allowances to farmers for damages as a result of the drain construction, farmers bear only 12.5 percent of the direct costs of the drainage projects. Given the situation of farmers bearing a proportion of costs more in keeping with the apportionment of benefits, many drains with poor benefit-cost figures might never have been initiated.

The major recommendations for the federal government in light of the revealed problems and inadequacies of the program are as follows:

1) In order for a more thorough evaluation to be done, the DPRC must be provided with a wider range of information concerning any drain under review. Additional technical support may be needed.

2) The DPRC must be provided with an effective mechanism for the evaluation of drainage proposals. This includes the possibility of a "no approval" option.

3) An environmental assessment of the Municipal Outlet Drainage Program should be conducted prior to any extension of the program or the commencement of any new one.

4) The approval process for subsidies for drainage should be removed from the restrictions of the Ontario Drainage Act.

5) A system of calling for tenders should be put in place for the selection of an engineering firm. Without this there are no safeguards on costs and little accountability.

6) The general means of evaluation for federal assistance for farmers should consider the implementation of a policy of helping farmers to adjust their operations to the land resource base rather than attempting to alter the land resource to fit the farm operation.

7) Any review body for any extension of the present program, or for any future federally funded drainage program, should include representation from the federal department with the environmental mandate.

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1. INTRODUCTION

Agriculture in eastern Ontario is a major basis for the area's economy, however, it is generally less prosperous than agriculture in other parts of southern Ontario. Several factors account for this, including differences in climate, soils, availabilty of agricultural services and facilities, and proximity to markets.

In 1979 the Federal and Ontario Governments began the Municipal Outlet Drainage Program as part of the Eastern Ontario Subsidiary Agreement. The program addresses one aspect perceived to be, in part, responsible for the lower agricultural productivity in eastern Ontario. It was anticipated that farm output and net income would be improved by providing financial assistance for the construction of municipal drains.

Excess water is a common condition in many areas being used or being considered for agricultural production in eastern Ontario. Removing this excess water may have considerable agricultural benefit, including (Irwin, 1979):

- increased soil aeration and improved water holding capacity,
- higher soil temperature,
- better soil structure and increased soil bearing capacity,
- improved efficiencies in machinery use, and
- better crop yields and improvements in crop quality.

In Ontario, drainage is most often accomplished by the construction of lateral surface drains or the installation of subsurface field drainage systems. For these to work efficiently, outlets must be provided for the water drained from the fields. To accomplish this, municipal outlet drains are constructed. These generally consist of engineered ditches.

Despite the recognized benefits, primarily to individual farmers, from agricultural land drainage, significant untoward environmental effects which impact on society at large may result from the practice (Hill, 1975; Day et al., 1976). These include the potential for impairment on water quality downstream, possible detrimental impacts of stream flow regimes, and the decline of wildlife and fish habitat through the loss of wetlands and other natural areas.

At report writing, the federal budget of the Municipal Outlet Drainage Program has been assigned to 252 municipal drain proposals. A number more have been approved should additional monies be granted to the program.

Despite the cited benefits, concern has been expressed over the efficiency of expenditures on drainage. There has not been a concerted effort made to investigate the effectiveness of government subsidies in being able to target support to those agricultural lands which possess the greatest potential for benefit from agricultural land drainage. Indeed, the point has been expressed (Kettel and Day, 1974; Bardecki, 1981) that given the present mechanisms for administering the practice, subsidies for agricultural land drainage act so as to make projects which are economically unwise on a broad, macroeconomic

basis appear viable, since the individual land owners have to bear only a portion of the total costs of such projects.

This study provides a preliminary appraisal of the effectiveness of the Municipal Outlet Drainage Program as it relates to the land resource. In particular, the capability of the Program to target funds to those areas providing the greatest potential for realizing benefit from land drainage is considered. In addition, the general compliance of the Program with the Federal Policy on Land Use (Government of Canada, 1981) is assessed.

2. CURRENT APPROACH TO SUBSIDIZING OUTLET DRAINAGE IN EASTERN ONTARIO

The federal government through the Department of Regional Economic Expansion (DREE), under the authority of the Canada-Ontario General Development Agreement[1], entered into the five year Eastern Ontario Subsidiary Agreement (EOSA) in 1979. This agreement provides funding assistance for the development of economic opportunities in the Eastern Ontario Planning Region. As part of the agricultural program of this agreement, approximately $11 million were made available for the Municipal Outlet Drainage Program.

Agricultural drainage construction and maintenance in Ontario fall within the jurisdiction of two provincial Acts: the Drainage Act and the Tile Drainage Act. The Drainage Act provides the administrative procedures for the construction and maintenance of municipal outlet drains; the Tile Drainage Act governs on-farm (i.e. field) drainage works.

The Drainage Act provides formal status for three procedures for the construction of municipal outlet drains: Mutual Agreement, Requisition, and Petition Drains. Neither of the first two are widely used in practice[2].

By far the greatest number of outlet drains constructed are Petition Drains. It is the construction of these that the EOSA was designed to support.

Petition Drains involve a somewhat involved procedure. A detailed outline of this process is provided by Irwin (1976). The procedure is initiated by the land owner or owners who desire the drainage works. They have to circulate a petition and obtain the names of the majority of land owners in the area, or the names of the owners holding 60 percent of the area requiring drainage.

The Municipal Outlet Drainage Program was designed to drain wet soils in eastern Ontario as a measure of improving agricultural yields. It provides assistance to municipalities on behalf of agricultural land owners in the form of grants for outlet drainage works. This grant covers two-thirds of the costs assessed against agricultural lands of those drainage schemes which meet the requirements of the outlet drainage program and those of the Ontario Drainage Act. Provision of the grant is apportioned equally from federal and provincial governments. The remainder (one third of the total cost assessed against agricultural lands) is paid by the landowners and includes assessments to both farmers requesting the drain and to any opposing it. The assessments are based on an allotment of benefit determined by the engineer, generally corresponding to the area of land owned within the drain basin. The engineer also determines any allowances that are to be paid to the owners of lands affected by

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[1] Since 1979 the Department of Regional Economic Expansion (DREE) has been replaced by the Department of Regional Industrial Expansion (DRIE) and the General Development Agreements have been replaced by Economic and Regional Development Agreements.

[2] Mutual Agreement Drains involve the formal agreement of two or more land owners to construct drainage works; Requisition Drains provide for the construction of relatively minor works with unanimous consent of the affected land owners by requisition to the Municipal Council.

the drainage works for losses or damages resulting from the project.

An eligible drain under the Municipal Outlet Drainage program must: be a new drain or consist of major improvements or reconstruction; comply with the terms of the Ontario Drainage Act; and be of measurable benefit to agriculture. Measurable benefit appears to have been interpreted by the Program as gross benefit (i.e. benefits without consideration of costs) rather than net benefit; all agricultural lands or lands potentially used for agriculture are assumed to receive some benefit from drainage.

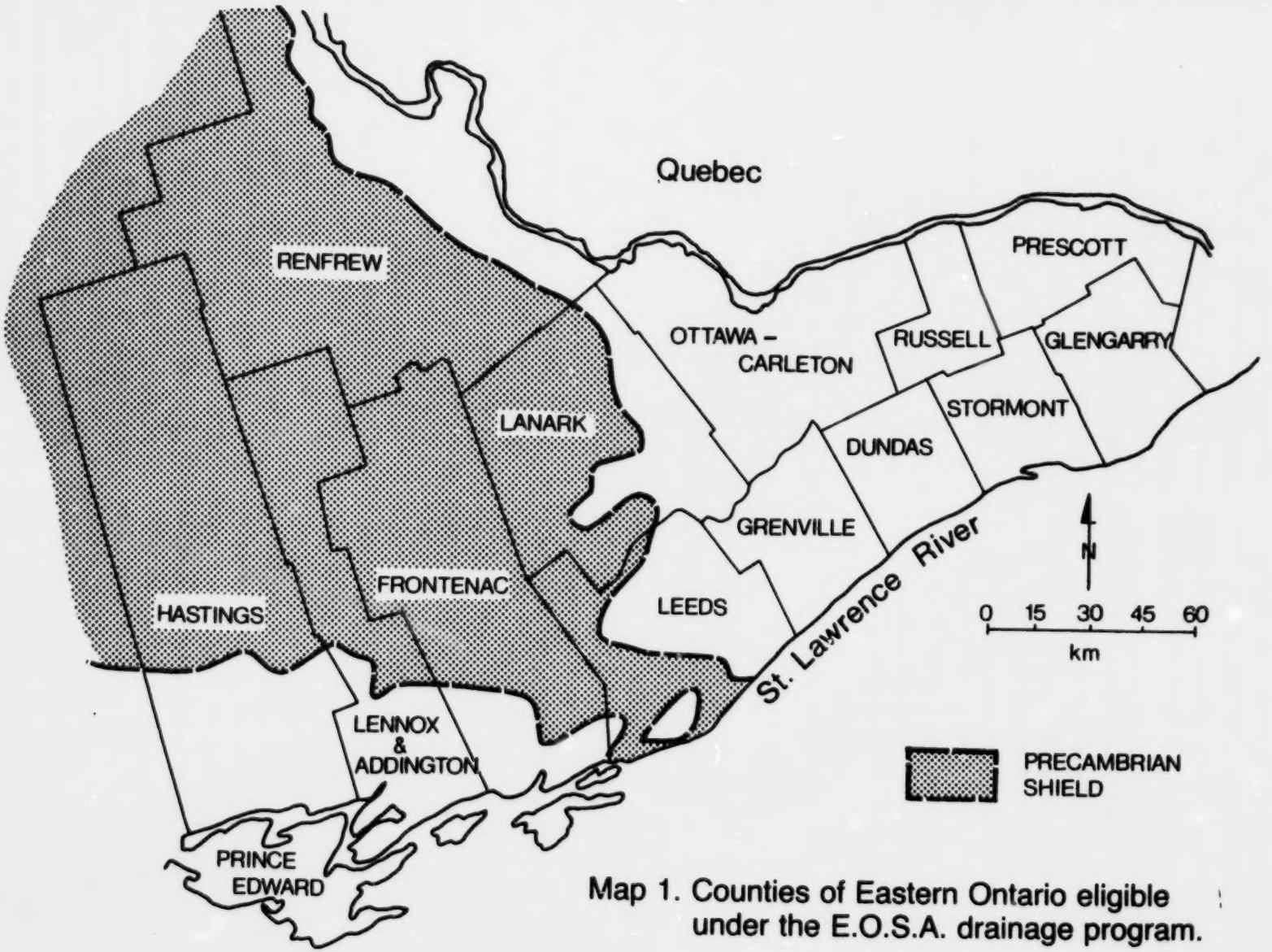
Only those municipalities within the 14 county units of eastern Ontario can apply; these include the county units and Regional Municipalities of Ottawa-Carleton, Frontenac, Hastings, Lanark, Leeds-Grenville, Lennox and Addington, Prescott-Russell, Prince Edward, Renfrew, and Stormont-Dundas and Glengarry (Map 1). Drains are considered on a "first come" basis with no formal mechanism to target those lands within the eligible municipalities most appropriate for drainage. Applications (i.e. Form 1; a copy of which may be found in the Appendix) which have been signed by the farmers who are petitioning for the drain are forwarded to the Drainage Petition Review Committee (DPRC) for consideration.

The DPRC is comprised of representatives appointed by various federal and provincial departments and ministries including Agriculture Canada, the Ontario Ministries of Natural Resources, the Environment, and Agriculture and Food, as well as the local Conservation Authorities. Environment Canada was included in the DPRC late in the program, in January 1982. The role of the DPRC is to review the technical aspects of the drain applications and make recommendations to the Agricultural Subcommittee which is comprised of representatives of Agriculture Canada and the Ontario Ministry of Agriculture and Food. The Agricultural Subcommittee forwards its recommendations to the Management Committee of EOSA for a final decision.

The DPRC was provided with Review Procedures formally approved by the Management Committee in September 1981, one and a half years following the inaugural meeting of the DPRC, by which time most of the drains had already been approved. The DPRC may: approve the drain application as is; approve the drain application with conditions; or request an Environmental Appraisal. No drain refusal is allowed unless the drain passes solely through a built-up area. In practice, the duties of the DPRC are complicated by the fact that a limited amount of time is available for review (one month, normally), and by the fact that a number of drain petitions are often under review at the same time. An estimate of drain construction costs is rarely available at the DPRC approval stage.

Once the intital application is approved, an engineering firm is selected by the municipality to design the proposed drain. The selection is made without calling for tenders.

Originally, the EOSA was to comply with the requirements of the Ontario Environmental Assessment Act. DREE subsequently decided that the DPRC and the environmental appraisal provisions in the Ontario Drainage Act would be sufficient to deal with potential environmental disturbances that could result



Map 1. Counties of Eastern Ontario eligible under the E.O.S.A. drainage program.

from drain construction (Dallimore, 1981). Since, under the Ontario Drainage Act, no requirements exist for proponents of a drain to provide information or to make an assesment of the environmental impacts unless requested by the DPRC, the DPRC members must search for available information or make on-site inspections to obtain additional information in order to identify potential problems. Therefore, DPRC members either obtain the information themselves or request an Environmental Appraisal which would be paid by the EOSA. To date, because of the cost involved, only one Environmental Appraisal has been requested. In obtaining information themselves, DPRC members are constrained by the large number of drains, the part-time nature of their duties, and the relatively little data provided to them on the drain application (Form 1).

3. THE AGRICULTURAL CAPABILITY OF EASTERN ONTARIO SOILS

Soils in Canada have been described in terms of an agricultural capability classification system whereby they are rated for their ability to grow common field crops (Canada Land Inventory, 1972). The CLI rating system is a planning tool which permits informed land use and management decisions concerning the agricultural land resource. The analysis in the report is based on this system. In this section, the agricultural capability rating system is explained and the soils of eastern Ontario are described using the system. The relative significance of various soil classes is outlined in order to emphasize the importance of the best quality soils.

3.1 Soil Capability for Agriculture

The main data sources on the land resources of eastern Ontario appropriate to this study are the soils reports issued for each county. They represent the most detailed data which are available across the whole study area. The agricultural component of the study is concerned with the agricultural potential of the soils. Each county soils map has been interpreted in terms of the capability and limitations of each soil unit to sustain production of common field crops, based on a system developed by federal and provincial soils and agricultural experts. The interpreted map set is available as the Canada Land Inventory: Soil Capabilities for Agriculture. The maps used in this study are at a scale of 1:50,000 and are directly derived from the county soils maps. A series of maps were also published presenting generalized data at a scale of 1:250,000. These general maps are referred to in the study only for an overview of soil conditions in eastern Ontario.

The Soil Capability for Agriculture is applied to both agricultural and undeveloped (i.e. those with natural vegetation) areas. The classification system uses soil and climatic characteristics alone to determine the potential capability of those soils to produce common field crops under the assumption that the land has been cleared and is under good soil management practices. Factors such as location, access, markets, or ownership have no bearing on the capability rating.

Specialty crops such as tobacco and tree fruits are not considered as part of the capability rating. For this report, this is not an issue since the rationale for drainage in the documents submitted to the Drainage Petition Review Committee was for the development of lands for common field crops rather than for specialty crops.

The CLI capability classification has two components: the capability class and the limitations. The class ranks the general capability of the soils for agricultural use. Class 1 is the best; Class 7, the worst. Class 1 land has no significant limitations for use in crops. Class 2 has moderate limitations that restrict the choice of crops, or require moderate conservation practices. Class 3 soils have moderately severe limitations that further restrict the range of crops, or require special conservation measures. Classes 1 to 3 are considered to be capable of sustained production of common field crops. Class 4 land has severe limitations so that it is suitable for few crops, the yields are low, or the risk of crop

failure high. Class 4 soils are considered to be marginal for sustained arable culture. Class 5 soils possess very severe limitations that generally limit their use to the provision of improved pasture. Class 6 land is capable only of supporting unimproved pasture. Class 7 has no capability for arable culture or for permanent pasture (Canada Land Inventory, 1972).

The limitations provide information on the kinds of problems to agriculture inherent in each soil unit. The class represents the relative degree of such limitations. Examples of limitations are low fertility, stoniness, moisture limitations which make soils susceptible to droughtiness, rock within three feet of the surface, steep slopes, and excess water.

The limitation of excess water (W) will be the main one referred to in this study. The Canada Land Inventory Report No. 2 (1972, 16) notes that, "Excess water may be the result of poor soil drainage, high water table, seepage or run-off from surrounding areas". In Ontario, these conditions are found within soils which are classified on the county maps as very poorly drained or poorly drained. Where it is feasible for an individual farmer to improve the productivity of wet soils through on-going management practices and on-farm improvements, then the CLI capability class reflects the productivity potential of the soil under assumed good management, but the wetness limitation is still designated. The CLI capability rating does not, however, reflect benefits to soil productivity derived from major reclamation works that involve cooperative actions among farmers or between farmers and governments. Reclamation projects such as municipal outlet drains may result in improved capability for soils limited by wetness. The wet soils most likely to receive benefit are those capable of the sustained production of common field crops (i.e. 2W and 3W).

Soils maps also distinguish imperfectly drained soils. While imperfectly drained soils are saturated for part of the year, the Canada Land Inventory did not consider their productivity under good management to be substantially limited because of wetness. Imperfectly drained soils are, as a result, usually grouped with the well drained soils. Indeed, in some instances, imperfectly drained soils may rate as more desirable than their well drained counterparts since they may retain needed moisture further into the growing season, thus being less susceptible to drought.

Three other soil limitations to agriculture are worth noting at this point. Rock within three feet of the surface (limitation R) generally prohibits or limits the use of sub-surface tile drainage. It is possible that certain soils susceptible to drought (M) might tend to be more susceptible following drainage. Steep slopes (T) generally allow for adequate water removal without the need for artifical drainage.

3.2 Organic Soils

In the Canada Land Inventory organic soils were classified separately with no capability indicated. Subsequent studies have interpreted the capability of organic soils for agriculture. In eastern Ontario, organic soils are often limited by their shallow depth and high degree of decomposition (Ontario Institute of Pedology, n.d.). Shallow depth

can limit the length of time that a deposit can be economically viable. A high degree of decomposition inhibits proper water level management. The exploitation of organic soils is also often hindered by the costs and difficulty of clearing such areas, and by the high cost of water level control structures. Only the deepest and best organic soils normally warrant these expenditures. Few such areas exist in eastern Ontario or elsewhere in the province. As an example, organic soils which were drained in Dufferin (Whitney et al., 1972) and Simcoe (Found et al., 1974) counties were found to be uneconomical to farm.

3.3 Soil Capability for Agriculture in Eastern Ontario

Table 1 illustrates some of the characteristics of the soil capability for agriculture of the fourteen counties in eastern Ontario eligible for the Municipal Outlet Drainage program. It shows that soils so limited by their rockiness and stoniness that they are incapable of supporting agriculture (7P/R) account for 41.8 percent of the region. These areas are largely on the Precambrian Shield which covers much of six counties (Map 1). If one removes the Shield area from consideration (Table 1), 23.0 percent of the remaining area is limited by wetness (W); 18.7 percent (390,000 ha) has a wetness limitation but is classed as capable of supporting sustained production of common field crops (2W and 3W). Generally, these 2W and 3W soils are the soils with the most capacity to benefit from drainage (D.W. Hoffman, pers. comm.). A relatively small proportion of the area (4.1 percent) is limited by wetness but marginal for crop production, or suitable only for permanent pasture (4W, 5W and 6W).

Considering only those seven counties (i.e., Glengarry, Prescott, Russell, Stormont, Dundas, Ottawa-Carleton, and Grenville) which are off the Shield and where 87 percent of all the agricultural drains in eastern Ontario have been constructed, one finds that 35 percent of this area is limited by wetness (W) (Table 2). Of this, 27.3 percent (255,000 ha) has a wetness limitation and is capable of sustained production of field crops (2W and 3W); while 7.7 percent is wet and marginal for field crops or suitable only for pasture (4W, 5W and 6W).

3.4 Research Validating the Soil Capability for Agriculture

Since the development of the Soil Capability for Agriculture classification system, research in southern Ontario has confirmed its validity. Hoffman (1971) measured yields of corn, oats and barley from soils of different classes. He found similar proportional decreases in yield for each crop from Class 1 through to Class 4. No figures were possible for Classes 5, 6 or 7 since farmers seldom attempt to grow corn, oats or barley on these soils; Hoffman found only one percent of his corn study sites to be on Class 4 soil and none on soils rated more poorly. Patterson (1975) studying the influence of soil capability on the economic returns for grain corn production, found very few sites on lower than Class 2 soils. For common field crops and with good management, Hoffman estimates that the yield from Class 2 soils to be approximately 80 percent of that from Class 1 land; Class 3, approximately 64 percent; and Class 4, 49 percent. He found that the results from eastern Ontario did not differ

TABLE 1

SOIL CAPABILITY FOR AGRICULTURE IN EASTERN ONTARIO (14 COUNTIES)*

Soil Class	Proportion by area
7P/R	41.8%
Other	58.2%
	100.0%

Soil Class	Proportion by area
2W	7.9%
3W	10.8%
4W	1.7%
5W	2.2%
6W	0.2%
7W	0.2%
Organic	10.5%
Other	66.5%

* Refer to Map 1.

Source: Canada Land Data System (1980); derived from the Canada Land Inventory 1:250,000 maps.

TABLE 2

SOIL CAPABILITY FOR AGRICULTURE OF THOSE COUNTIES OF EASTERN ONTARIO THAT ARE COMPLETELY OFF THE PRECAMBRIAN SHIELD*

Soil Class	Proportion by Area
2W	12.8%
3W	14.5%
4W	3.1%
5W	4.3%
6W	0.3%
7W	0.05%
Organic	10.4%
Other	54.6%
	100.0%

* i.e. Glengarry, Prescott, Russell, Stormont, Dundas, Ottawa-Carleton, and Grenville.

Source: Canada Land Data System (1980).

from those for the rest of Southern Ontario.

A later study (Centre for Resources Development, 1977) examined the influence of both class and limitation. In each class no significant difference in yield for common field crops was found among the various limitations. Yields from corn, from land with a limitation due to wetness, corresponded class by class to the yield estimates derived by Hoffman.

Studies of forage crops have shown a similar relationship among classes (Anderson, 1971). Compared to Class 1, Class 2 soils yield 80 percent; Class 3, 66 percent; Class 4, 58 percent; and Classes 5 and 6, 49 percent.

All of the studies tested sites which had a high degree of management. In the case of soils limited by wetness, the yields reflect the situation after drainage.

Several studies have assessed the relationship between economic returns realized and soil class. Patterson (1975) found that grain corn growers on Class 2 land averaged 68 percent of the gross margin per hectare attained by growers on Class 1 land.

Noble (1965) developed indices for farm labour by soil class for farms in eastern Ontario. Compared to Class 1, Class 2 soils return 87 percent of the labour income per area; Class 3, 75 percent; Class 4, 33 percent; Class 5, 25 percent; Class 6, 20 percent; and Class 7, 0 percent. The Committee on Farm Assessment and Taxation (1969) rated the market value of land for farming purposes. Compared to Class 1, Class 2 is worth 92 percent; Class 3, 72 percent; Class 4, 30 percent; Class 5, 15 percent; Class 6, 10 percent; and Class 7 land, 7 percent.

3.5 Summary

The Canada Land Inventory developed a system for the classification of soils according to their capability to produce common field crops under good management. Research in southern Ontario has confirmed the classification system and demonstrated the relative significance of soils of CLI Classes 1, 2 and 3.

Although other soils may be usefully drained under certain circumstances, it is those soils limited by wetness and which possess a reasonable capability for crop production (i.e. 2W and 3W) that are most likely to show net benefit from the construction of outlet drainage systems. About 18.7 percent of the land area in eastern Ontario (390,000 ha) consists of these soils.

4. THE STUDY AND PRELIMINARY RESULTS OF THE DRAINAGE PROGRAM

In this section, details of the study methodology and data sources are briefly outlined. Preliminary results relevant to this study are also presented in a generalized way, primarily in the form of graphs and tables. Some of the more salient features of these data are described. A more detailed discussion can be found in Section 5.

4.1 Drains Surveyed and Data Studied

A survey of 64 drains was undertaken to provide a preliminary indication of the results of the Municipal Outlet Drainage Program in eastern Ontario. The surveyed drains were those with engineering reports available to the Lands Directorate, Ontario Region, Environment Canada. Several drains with available engineering reports were not included, however, due to the absence of a plan map, incomplete cost figures, or the unavailablity of agricultural capability maps for the area in question. The surveyed drains are generally representative of all drains under the Program both in terms of their spatial distribution (Table 3) and in the range of total costs involved. Table 4 provides a list of the 64 drains included in this survey[3]. The drains under scrutiny constitute 25.4 percent of all the drains which had been submitted to the DPRC until federal funds had been completely allocated. The 64 drains comprise a total of 252 km of drain length and were proposed to provide outlet for a total of 34,311 ha of land. For each drain, specific data were obtained from several sources[4]. These data include:

- the type of drain construction (i.e. involving new construction, major improvements/ deepening, or a combination of both);
- total drain length;
- the area of the drainage basin as reported on Form 1 and in the engineer's report;
- the area of the various agricultural soil capability classes and subclasses found within the drainage basins (particularly the areas of the various classes affected by wetness limitation, the areas of organic soils, imperfectly drained soils[5], and soils exhibiting limitations due to moisture deficiency, topography and shallow depth to bedrock);

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[3] Of the 64 drains, 25 were new construction, 29 involved major improvements/deepening and the remainder (10 drains) were a combination of new construction and reconstruction.

[4] These sources include: the engineer's reports which incorporate plan maps of the drain locations and of the drainage areas for which assessments were determined; the application forms for assistance as provided to the DPRC (Form 1); Canada Land Inventory maps of soil capability for agriculture (1:50,000 scale); county soils maps; and maps of the Wetland Mapping Series (Second Approximation) as developed by the Lands Directorate, Ontario Region, Environment Canada (1:50,000 scale). Data not provided directly from the engineer's reports or from Form 1 (in actuality, for about one-third of the drains under study, no Form 1 was available) were obtained by overlaying the various maps and determining the appropriate values by direct measurement or by means of a dot grid.

[5] In the case of soil limitations such as insufficient depth to bedrock (limitation R), soils may be imperfectly drained but are classified only by their nominal limitation (in this example, R).

TABLE 3

MUNICIPAL DRAINS SUBMITTED TO THE DPRC SURVEYED IN THIS STUDY, BY COUNTY

County	252 Drains Submitted to DPRC		64 Drains Surveyed in this Study	
	Number	Percent	Number	Percent
Hastings	1	0.4	0	0
Renfrew	14	5.6	2	3.1
Lanark	5	2.0	1	1.6
Lennox & Addington	1	0.4	1	1.6
Frontenac	3	1.2	1	1.6
Grenville	9	3.6	6	9.4
Leeds	8	3.1	3	4.7
Stormont	30	11.9	3	4.7
Prescott	69	27.4	29	45.3
Glengarry	37	14.7	6	9.4
Russell	27	10.7	4	6.3
Ottawa-Carleton	20	7.9	4	6.3
Dundas	28	11.1	4	6.3
Prince Edward	0	0	0	0
TOTAL	252	100.0	64	100.0

Statistical representativeness of the sample of drains: Chi-square = 17.32; Significance Level = 13.8%

TABLE 4

LIST OF 64 MUNICIPAL DRAINS SURVEYED IN EASTERN ONTARIO FOR THIS STUDY

Drain Number	Drain Name	Township	County
3-18	Payne River Drain	Roxboro	Stormont
81-1	Mud Creek	Augusta	Grenville
81-2	Miller Drain	Amherst Island	Lennox & Addington
81-7	Lyn-Pettem	Elizabethtown	Leeds
81-58	Eldon Quaile	Osgoode	Ottawa-Carleton
81-60	Arcand Drain	South Gower	Grenville
81-68	Greer	Elizabethtown	Leeds
81-129	Prophet	Osgoode	Ottawa-Carleton
81-131	Lionel Levac	Caledonia	Prescott
81-133	Reed Bay	Wolfe Island	Frontenac
81-134/150	Healy-MacPherson	North Elmsley	Lanark
81-135	Den Otter	Charlottenburgh	Glengarry
81-136	Slater Fraser	Lochiel	Glengarry
81-140	Leo Binette	East Hawkesbury	Prescott
81-145	Marselis	Williamsburg	Dundas
81-147	Cotnam	Pembroke	Renfrew
81-148	Creek Road	Front Leeds & Lansdowne	Leeds
81-149	Phillippe Blanchard	Cambridge	Russell
81-153	Trottier	East Hawkesbury	Prescott
81-155	Roma Burnet	East Hawkesbury	Prescott
81-156	Remi Lavigne	East Hawkesbury	Prescott
81-157	C. Bernique	East Hawkesbury	Prescott
81-159	Rene Besner	Caledonia	Prescott
81-160	Roland Seguin	East Hawkesbury	Prescott
81-162	Guy Tranchemontagne	East Hawkesbury	Prescott
81-163	Gilles LaFrance	East Hawkesbury	Prescott
81-164	Des Castors	Cambridge	Russell
81-166	Ubald Tasse	Cumberland	Ottawa-Carleton
81-169	Workman-Norton	South Gower	Grenville
81-172	Piche	South Plantagenet	Prescott
81-173	Louis Claude	Alfred	Prescott
81-174	Ferguson	Wolford	Grenville
81-175	Melvin D. Gardner	Lancaster	Glengarry
81-176	Armstrong	West Carleton	Ottawa-Carleton
81-177	Wilson	South Plantagenet	Prescott
81-178	Patt-Rowe	South Plantagenet	Prescott
81-179	Cambal	Lochiel	Glengarry
81-180	Fetterly & Dunbar-Campbell-Adams	Finch	Stormont
81-182	Connell	Edwardsburgh	Grenville
81-183/185	Romeo Sauve	South Plantagenet	Prescott
81-189	Cahill	Bromley	Renfrew
81-190	Geo. Barkely	Williamsburg	Dundas
81-191	Willems	East Hawkesbury	Prescott
81-193	Donat Duplantie	East Hawkesbury	Prescott
81-194	Yvon Clement	East Hawkesbury	Prescott
81-195	Nixon	East Hawkesbury	Prescott
81-192/196	Ray Conway-Keller	East Hawkesbury	Prescott
81-197	Edouard Dicaire	East Hawkesbury	Prescott
81-198	Trottier Major Imp.	East Hawkesbury	Prescott
81-199	Muir	South Plantagenet	Prescott
81-200	Suprenant-Racine	East Hawkesbury	Prescott
81-201	Menard Moss	Russell	Russell
81-202	Sylvio Pilon	Russell	Russell
81-203	Cross Creek	Caledonia	Prescott
81-204	Genier	Finch	Stormont
81-205	C. Beaulieu	Lochiel	Glengarry
81-206	Saddlemire	Williamsburg	Dundas
81-207	Lionel Rozon	Kenyon	Glengarry
81-208	Maitland	Wolford	Grenville
81-212	Ranger Major Imp.	East Hawkesbury	Prescott
81-213	Eric Mooney Major Imp.	East Hawkesbury	Prescott
82-233	Williamsburg Village	Williamsburg	Dundas
82-236	Borris	West Hawkesbury	Prescott
82-242	Ronald Barton	West Hawkesbury	Prescott

- the length of drain which actually passes through the various soil capability classes and subclasses;

- the length of drain passing through wetlands;

- the area of wetlands found within the drainage basin and the soil capabilities associated with the wetlands;

- the total cost of the drainage scheme as indicated by the engineer's report;

- the net cost to farmers, and the cost in grants to the federal and to the provincial governments;

- the value of other costs to government, including assessments to federal and provincialy owned land, provincial highway crossings, and assessments to county and township roads.

4.2 Soil Capability for Agriculture in the Drain Area

For purposes of this discussion, a distinction is made between wetlands as defined by Snell (1981) and other soils. Those wet soils (i.e. organic soils and those with a limitation of excess water in the Canada Land Inventory classification) with natural vegetation cover are considered to be wetlands and are identified as such by the Wetland Mapping Series. All other wet soils without natural vegetation cover are referred to as cleared and are generally cultivated or in pasture (Snell, 1981). Wetlands may be defined more generally as any area with saturated soils for all or most of the year and with natural vegetation adapted to such conditions. Wetlands are usually classed as swamp, marsh, bog, or fen.

Table 5 shows that of the total area within all 64 drain basins, 28.5 percent is composed of cleared areas of soil capability classes 2W and 3W. Cleared areas of other soils limited by wetness (4W, 5W, 6W and 7W) constitute 5.9 percent of the drain areas. Areas of cleared organic soils constitute 3.3 percent of the area.

Many of the 64 drains' basins contain a low proportion of wet and imperfectly drained soils (Figure 1). About 50 percent of the drainage area consists of soils possessing no limitations to agriculture (Class 1) and soils with limitations other than wetness. Indeed, some soils in the drainage areas may be generally unsuitable for drainage; 7.3 percent of the areas' soils are subject to drought (limitation M), and 5.7 percent is soil limited by shallowness (limitation R) where tile installation would be difficult.

Wetlands, which are most often found as treed swamp and bog in eastern Ontario, make up 11.8 percent of the basins.

4.3 Soil Capability for Agriculture of Soils Adjacent to Drains

An examination of the length of drain which passes through the various agricultural soil capability classes provides a means of illustrating the relationship of the drains to soil types (Table 6).

Although only 1.0 percent of the drain length passes through cleared organic soils, 50.9 percent of the length was through

TABLE 5

SOIL CLASSIFICATION STATISTICS OF THE 64 DRAIN BASINS SURVEYED IN EASTERN ONTARIO

Soil Capability Class for Agriculture	Area of Drain Basins (ha)	(percent)	
Non-Wetland Soils			
2W	2,819	8.2	28.5
3W	6,953	20.3	
4W	226	0.7	
5W	1,579	4.6	5.9
6W	126	0.4	
7W	64	0.2	
Organic	1,140	3.3	3.3
Imperfectly Drained	7,479	21.8	50.5
Other (Well Drained)	9,839	28.7	
Vegetated Wetlands			
2	604	1.8	11.8
3	574	1.7	
4	232	0.7	
5	566	1.6	
6	16	0.1	
Other & Unclassified	73	0.2	
Organic	1,940	5.7	
TOTAL AREA	34,311	100.0	

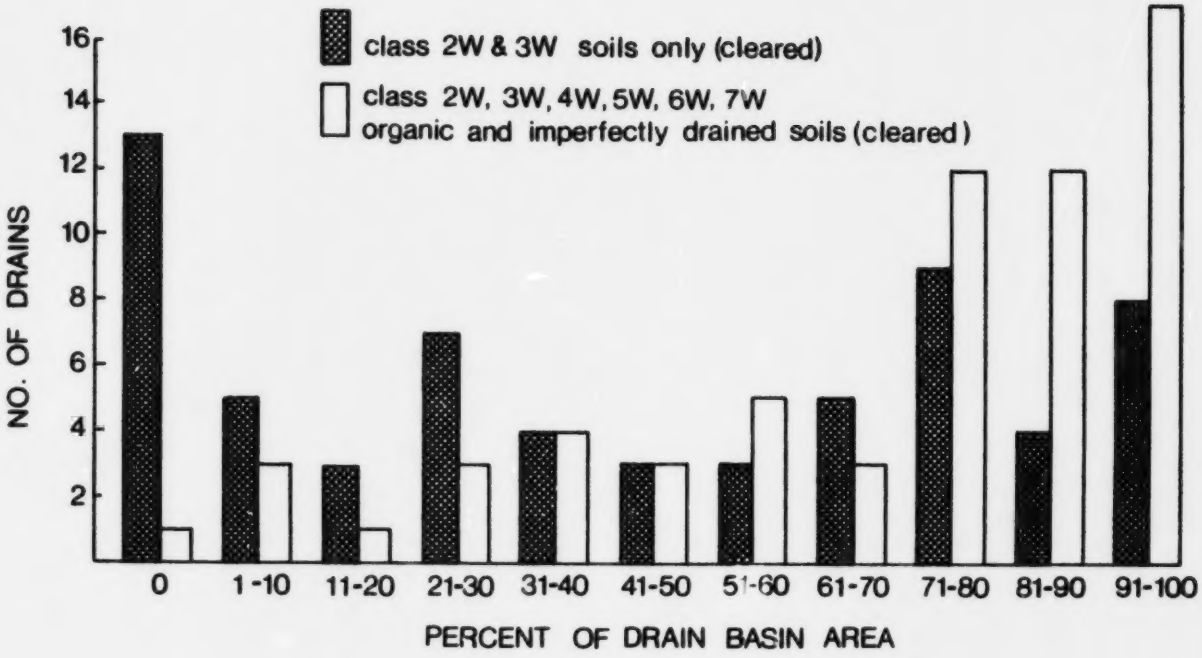

Figure 1. Range in percentages of wet and imperfectly drained soils of 64 drain basins surveyed.

TABLE 6

LENGTH OF DRAIN PASSING THROUGH VARIOUS AGRICULTURAL CAPABILITY SOIL CLASSES OF THE 64 DRAINS SURVEYED IN EASTERN ONTARIO

Soil Capability Class for Agriculture	Length of Drain (meters)	(percent)	
Non-Wetland Soils			
2W	28,579	11.3	50.9
3W	99,680	39.6	
4W	4,905	1.9	
5W	14,074	5.6	9.3
6W	2,026	0.8	
Organic	2,437	1.0	
Imperfectly Drained	46,204	18.3	33.6
Other (Well Drained)	38,658	15.3	
Vegetated Wetlands			
2	2,310	0.9	6.1
3	2,156	0.8	
4	926	0.4	
5	2,156	0.8	
6	154	0.1	
Other & Unclassified	308	0.1	
Organic	7,392	3.0	
TOTAL LENGTH	251,960	100.0	

cleared 2W and 3W soils, and 8.3 percent through other cleared soils limited by wetness (i.e. 4W, 5W, 6W and 7W). About 6.1 percent of the total length of the drains surveyed passed through wetlands.

4.4 Wetlands

Wetlands, provide a number of important benefits (Bardecki, 1984b). From a biological point of view, they are among the most productive of ecosystems, providing key habitat for significant numbers of species of both plants and animals. Although there are many species which primarily inhabit wetlands, wetland areas also allow for larger populations and wider ranges for a great number of other organisms. Many species inhabiting wetland areas are important for their economic or recreational values.

Wetlands also contribute benefit in improving water quality, and may aid in modulation of stream flow. Further, wetlands provide educational and research opportunities in addition to their use for recreational pursuits such as hunting and nature study.

It is evident that in much of eastern Ontario, wetlands constitute a low proportion of the land area (Table 7). This is a reflection of the considerable losses in wetlands in the past; drainage pressure on the remaining wetlands is likely to remain high (Bardecki, 1984a). At the same time, the increasing scarcity of wetlands acts to increase their marginal value in the eastern Ontario region.

Since wetlands are a significant element in the natural resource base in eastern Ontario, an attempt is made in this study to determine the area of wetlands potentially affected by the Municipal Outlet Drainage Program. Wetlands may be affected by the drainage program in two ways: 1) through direct damage from drain construction through the wetland; or 2) by subsequent clearing with sub-surface or surface lateral drainage of wetlands in the drain basin. Of the 64 drains under study, 6.1 percent of the total length of drain construction was through wetlands (Table 6). Some of this represents drain reconstruction through wetlands which had been affected previously, at least to some extent, but 1.8 percent of all drain length was of new drains through wetlands. Wetlands constitute 11.8 percent of the total drainage area (4,500 ha) and 29.4 percent of these wetlands (1,178 ha) is of soil capability classes 2W and 3W (Table 5), these being the wet soils most likely appropriate for agriculture.

Most drain basins contain a small proportion of wetlands, although several do possess a relatively high percentage (Figure 2).

4.5 Cost Summary

The total cost for the 64 drains under study, as reported by the engineer's reports, is $8,011,108. The costs applicable solely to the agricultural portions of the drains are equally assessed to the farmers, the federal government and the provincial government (Table 8). Slight differences in the proportions are due to other costs such as maintenance and minor improvements. In reality the actual dollar cost to the farmers is considerably lower due to allowances made as a result of loss of crops and land. It is important also to note that the governments actually bear more costs than just the grant portions. Road and highway crossings put a

TABLE 7

AREA AND PERCENTAGES OF CURRENT WETLANDS BY TOWNSHIP IN WHICH

252 DRAINS WERE LOCATED

County Township	Area of Wetlands (ha)	Total Area (ha)	Percent Wetlands
Dundas			
Williamsburg	5,873	25,079	23.4
Matilda	3,182	64,164	5.0
Mountain	3,362	63,457	5.3
Winchester	1,453	61,823	2.4
Frontenac			
Olden	1,199	66,470	1.8
Portland	2,824	54,350	5.2
Wolfe Island	617	13,516	4.6
Glengarry			
Charlottenburg	4,847	34,800	13.9
Lancaster	2,534	24,688	10.3
Lochiel	2,376	30,200	7.9
Kenyon	10,012	34,680	28.9
Grenville			
Augusta	4,591	31,310	14.7
Edwardsburgh	6,281	31,060	20.2
Oxford-on-Rideau	3,500	64,920	5.4
South Gower	1,137	8,565	13.3
Wolford	4,356	22,293	19.5
Lanark			
Beckwith	6,375	60,050	10.6
Drummond	6,568	60,350	10.9
Montagne	5,834	70,380	8.3
North Elmsley	2,560	12,475	20.5
Leeds			
Bastard & Burgess S.	1,409	65,760	2.1
Elizabethtown	4,932	33,203	14.9
Front Leeds & Lansdowne	2,119	28,555	7.4
Rear Leeds & Lansdowne	1,121	54,360	2.1
Lennox & Addington			
Amherst Island	536	7,845	6.8
Ottawa-Carleton			
Cumberland	4,464	31,767	14.0
Gloucester	2,914	101,258	2.9
Goulbourn	4,446	68,888	6.5
Osgoode	3,736	38,160	9.8
Rideau	7,255	101,208	7.2
West Carleton	4,003	62,488	6.4
Prescott			
Alfred	2,127	18,192	11.7
Ca'edonia	4,346	18,873	23.0
East Hawkesbury	1,935	23,910	8.1
North Plantagenet	1,853	50,800	3.6
South Plantagenet	1,893	20,870	9.1
West Hawkesbury	994	12,078	8.2
Renfrew			
No Data Available for Wetlands			
Russell			
Cambridge	8,090	25,120	32.2
Clarence	5,889	71,870	8.2
Russell	1,215	20,259	6.0
Stormont			
Cornwall	4,166	51,360	8.1
Finch	702	22,058	3.2
Osnabruk	5,355	59,800	9.0
Roxboro	5,074	74,560	6.8
Hastings			
Huntingdon	2,040	54,195	3.8
TOTAL (45 townships)	162,095	1,952,067	8.3

Sources: Lands Directorate, Ontario Region: Wetland Data for Southern Ontario (based on 1966 information).
Hoffman and Noble (1975).

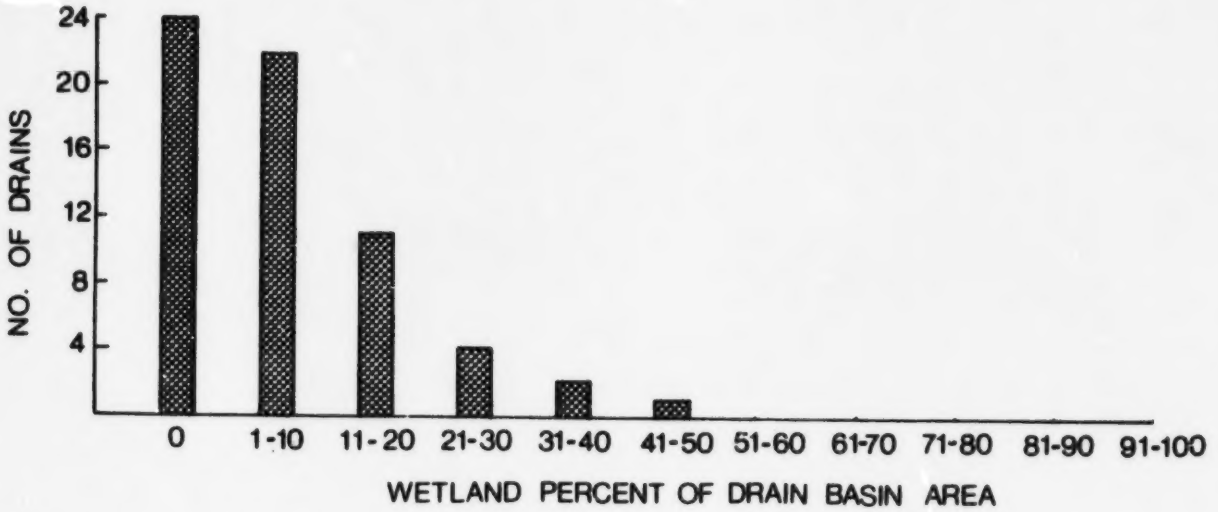

Figure 2. Range in wetland percentages of 64 drain basins surveyed.

TABLE 8

COSTS SUMMARY OF 64 MUNICIPAL DRAINS SURVEYED

	Costs ($)	Percent	
Total Cost to Farmers (monetary)	1,002,815	12.5	29.5
Total Allowances to Farmers	1,364,297	17.0	
Total Cost to Federal Government	2,304,642	28.8	
Total Cost to Provincial Government	2,319,408	28.9	
Other Costs to Governments (municipal - roads; provincial - A.R.D.A., highways; federal - property owned)	814,443	10.2	
Total Cost to Private Non-Agricultural Landowners	205,503	2.6	
TOTAL COST AS PER ENGINEER'S REPORTS (64 DRAINS)	8,011,108	100.0	

further cost burden on municipal and provincial coffers as does drain construction through publicly owned lands.

4.6 Cost Averages and Ranges

In studying the effectiveness of a drainage program, the costs of drainage as well as the quality of lands being drained are of vital consideration. Cost averages, ranges and totals to the various parties involved in the drainage program, therefore, are presented.

The average cost per metre of drain borne by farmers and by the federal government through grants, and the average allowances granted to farmers for the 64 drains under study are shown in Table 9. These average costs are presented for each of the types of drain construction (i.e. new drains, improved/deepened, and combination drains) as well as for all drains. A wide range of costs occurs (Figure 3); this may well be a result of differing numbers of road and railway crossings as well as other costs which are not typical of all drains. More control over some costs may, however, be indicated; further study would be required to establish this.

The average cost per metre for all drains surveyed is $32.00 (Table 9). For all types of drains, the average allowance per metre of drain to farmers is greater than the average cost to farmers per metre of drain. Combination drains have higher average federal grants and farmer allowances per metre of drain.

Costs can also be compared on the basis of the area of land drained. Figure 4 illustrates the range in the total cost per hectare of the 64 drains under study. Also included are data for the total cost of the drains per hectare of soil of Classes 2W and 3W and for the total cost of the drains per hectare of soils having any indication of excess water (i.e. all soils limited by wetness, organic soils and imperfectly drained soils). As with the costs per metre of drain, the cost per hectare is affected by the number of road and rail crossings as well as by other factors. Of note is the high cost of drain construction per hectare of Class 2W and Class 3W soils in the drainage basin.

4.7 Summary

In summary, of the 64 drain basins surveyed, 28.5 percent of the area consisted of soil classes 2W and 3W, while 50.5 percent of the area had no limitations to agriculture, or limitations other than excess water. Wetlands comprised 11.8 percent of the drain basins.

Of the total drain length, 50.9 percent passed through soil classes 2W and 3W. About 6.1 percent of the total length of the surveyed drains passed through wetlands.

Wetlands in the 64 basins totalled about 4,000 ha. Several drains possess relatively high proportions of wetlands in their basins.

The average cost per metre of drain was $32.00. A great range exists in the costs of individual drains both on a per metre and on a per hectare basis.

TABLE 9

AVERAGE COST PER METRE OF DRAIN OF 64 DRAINS SURVEYED

TOTAL, FEDERAL AND FARMER COMPONENTS ONLY

	All Drains*	New Drains	Improvement/ Deepening Drains	Combination Drains (Part New & Part Improved)
Average Total Cost per m of Drain**	$32.00	$35.00	$28.00	$35.00
Average Cost to Farmer per m of Drain	$ 3.98	$ 3.81	$ 4.54	$ 2.69
Average Allowance to Farmer per m of Drain	$ 5.41	$ 4.39	$ 4.89	$ 8.74
Average Cost of Federal Government (grant) per m of Drain	$ 9.15	$ 7.83	$ 9.19	$11.43

* Of 64 Drains Surveyed: 25 were New Construction
29 were Improvement/Deepening
10 were Combination.

** The average total costs per metre also include provincial costs and other costs to governments, but these components are not separated on a per metre basis in this table.

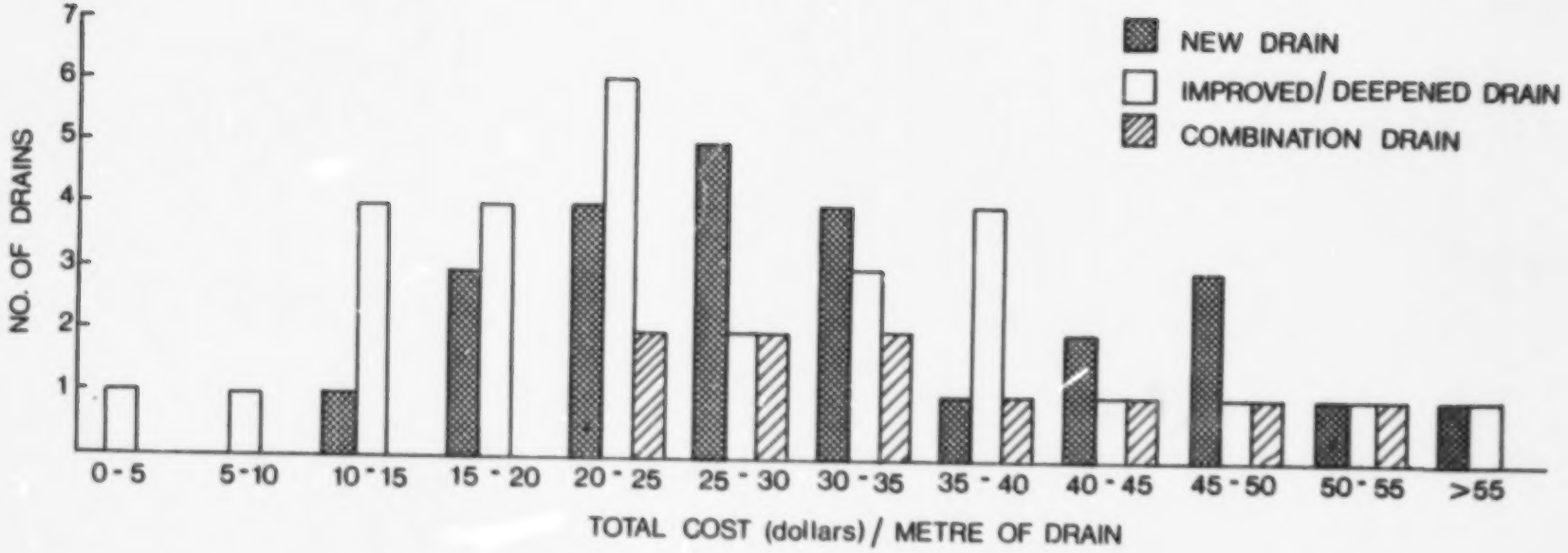

Figure 3. Range in total cost per metre of drain for 64 drains surveyed.

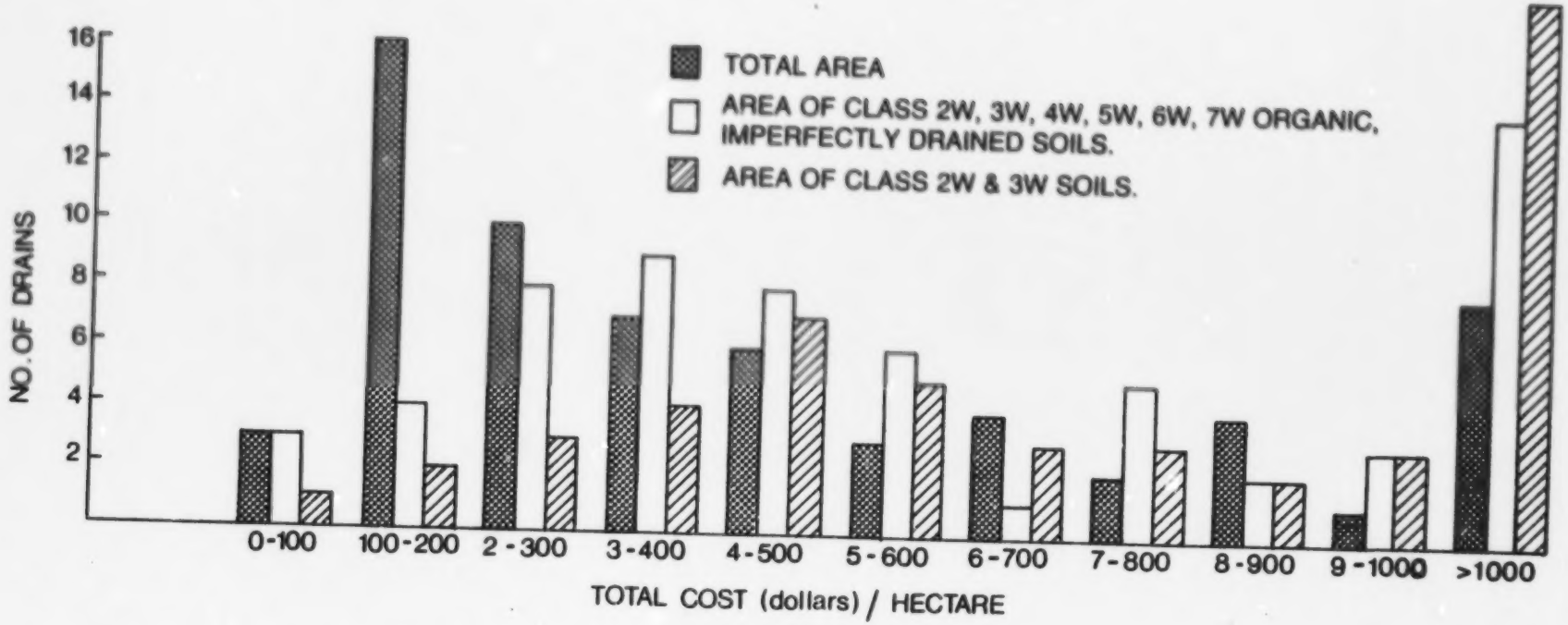

Figure 4. Range in the total cost / hectare of 64 drains surveyed.*

* Basins where there are no soils of the specific classes noted are not plotted.

5. THE EFFECTIVENESS OF THE MUNICIPAL OUTLET DRAINAGE PROGRAM

The effectiveness of the Municipal Outlet Drainage Program in achieving desired goals for the overall benefit of the land resource of eastern Ontario and its users will be examined in this section. Although the program's initiation predates the inception of the Federal Policy on Land Use (Government of Canada, 1981), it is a federally funded program, and as such, conformity to the Policy will be examined, albeit in retrospect. The results are discussed in four sub-sections:

1) the ability of the program to target those lands most appropriate for drainage;

2) the wetlands affected by the program;

3) the degree of conformity to the Federal Policy on Land Use; and

4) the benefit-cost analysis of municipal drains.

5.1 Ability of the Program to Target Lands Most Appropriate for Drainage

5.1.1 Identification of Lands Benefitting from Drainage

As outlined above, eastern Ontario contains a high proportion of wet soils, not all of which possess a high capability for agriculture. Soils with an agricultural capability rating of Classes 2W and 3W are considered as the most likely to benefit from outlet drainage. As a group, they are the most capable of growing field crops, and the most cost effective to drain. Other soils limited by wetness (i.e. Classes 4W through 7W) possess relatively limited value for field crops even after drainage; as has been noted above, studies of the productivity to be expected on the various classes of soils have found very few areas of even Class 4 soils being used for crops (Section 3.4). Due to problems with limited depths and their high degree of decomposition, organic soils are often unsuitable and uneconomical to farm in this region of the province (as has been the case elsewhere). Imperfectly drained soils would receive relatively little benefit from the construction of outlet drains; the Canada Land Inventory considered the productivity of these soils not to be limited by wetness.

One feature of some physiographic areas in eastern Ontario is the "patchiness" of their soils, that is, several soil units may be found interspersed with one another. Small areas of poorly drained soils within fields may reduce the efficiency of farm operations; and there is often a desire on the part of farmers to drain these areas. Some such areas are at too small a scale to have been mapped by the Canada Land Inventory. The benefit realized from draining such areas is highly variable, but because of the generally small area involved on a drain by drain basis, the draining of these types of areas can seldom be the rationale for the construction of entire outlet drainage systems. The benefits on a broad scale are considered to be small; on-farm management alternatives can alleviate a great proportion of such problems.

Although the detailed appraisal of the soils of individual drains could provide a clear picture of those soils that might benefit from the construction of outlet drains, consideration of the general soil character as

defined herein provides a usefully broad perspective.

Considering the above, in this study, three hypotheses are forwarded concerning the classes of lands which are likely to receive benefit from drainage. First, it is assumed that all soils will benefit from drainage; as has been suggested above, this assumption is generally unrealistic and distorts significantly upwards the assumed benefits. The study also demonstrates the results of the assumption that benefit might be realized on all lands classed by the Canada Land Inventory as having any indication of excess water (i.e. all soils limited by wetness, all organic soils, and all soils which are classed as imperfectly drained). Finally, the hypothesis is forwarded that those lands limited by wetness and which possess at least a modest potential for crop production (i.e. 2W and 3W) are the only areas likely to receive benefit (Section 3.2). D.W. Hoffman (pers. comm.), a major figure in the development and application of the classification system for Soil Capability for Agriculture and its relationship to potential yields, feels that only classes 2W and 3W soils are generally worth the investment of drain construction.

It is impossible to precisely define which soils within a drainage basin will ultimately be affected by a drain since this is dependent on the nature of the basin, the distribution and type of soils, and where future surface lateral drains and sub-surface tile drains are constructed. Therefore, two approaches are used to test the ability of the drainage program to target those lands most appropriate for drainage.

In the first approach, it is assumed the whole basin is affected by the drain. Statistics are compiled on the total area of each agricultural soil capability class within each drain basin. This approach may tend to exaggerate a lack of targeting since most drainage basins include both soils worth draining and other drier areas that might not be near the drain. However, it is the total area within each basin that is used in assessing costs to land owners.

In the second approach, it is assumed only those soils immediately adjacent to the drain are directly affected by the drain. The drain length which passes through each agricultural soil capability class within each drain basin, was measured. This approach tends to exaggerate the ability of the drainage program to target lands since drains must go through the lowest and therefore, generally the wettest soils. The majority of the land within each drain basin is not considered.

5.1.2 Results

The results of the first approach, which considers the whole basin, are illustrated in Table 5. Of the total non-wetland area within the 64 drain basins under study, 28.5 percent (9,772 ha) consists of Class 2W and 3W soils. If these data are extrapolated to the complete drainage program, (i.e. the 64 drains are assumed to be representative of 252 drains) about 40,000 hectares of cleared Class 2W and 3W soils are to be found in the drain basins of projects under the Municipal Outlet Drainage Program (of 390,000 ha of 2W and 3W soils in the fourteen counties of eastern Ontario eligible for drainage assistance).

The total area of soils limited by wetness, organic soils, and imperfectly drained soils

(excluding wetlands) comprise 59.5 per cent of the total area of the 64 drain basins studied. Even when including these soils, which in most cases would derive only slight, if any, benefit from drainage, 28.7 percent of the total area consists of well drained soils which will receive at best, only very limited benefit. Some have a moisture deficiency (limitation M) or are very shallow and stony (R and P) and may be adversely affected by drainage. The remaining 11.8 percent of the area is wetlands.

Looking at individual drains surveyed, 21 of 64 drains (32.8 percent) have greater than 70 percent of their basins comprised of cleared Class 2W and 3W soils (Figure 1). A further eight drains (12.5 percent)have basins consisting of between 50 and 70 percent of these Class 2W and 3W soils. Thirteen drains have no Class 2W and 3W soils.

Forty-one of 64 drains have basins that consist of greater than 70 percent of non-wetland areas with soils limited by wetness, organic soils, and imperfectly drained soils; 49 drains have basins consisting of at least 50 percent of these classes. The basins of 3 drains (Greer 81-68, Connell 81-182, and Armstrong 81-176) have less than 10 percent of their area as cleared imperfectly drained, poorly drained and organic soils.

If one considers Class 2W and 3W soils as being a primary target for drainage, it would appear that the drainage program from a basin-wide perspective is only 28.7 percent effective in targeting class 2W and 3W soils. The program drains 2W and 3W soils in no greater frequency than would happen by random selection of areas in those seven counties in eastern Ontario which are off the Shield (Glengarry, Prescott, Russell, Stormont, Dundas, Ottawa-Carleton and Grenville). These counties consist of 27.3 percent class 2W and 3W soils (Table 2).

Allowing the gross assumption that all cleared wet, organic and imperfectly drained soils would receive benefit from drainage, on a similar basis, only 59.5 percent effectiveness in targeting is achieved. The wide range in percentages of wet soils in drain basins suggests a lack of consistency in identifying lands most able to benefit from drainage.

The results of the second approach, which considers only soils immediately adjacent to the drains, are illustrated in Table 6. The lengths of drains which pass through cleared Class 2W and 3W soils account for 50.9 percent of the total drain length. For the group of cleared wet, organic and imperfectly drained soil classes, the lengths of drains passing through them account for 81.5 percent of the total length of drain construction. These figures suggest a more effective targeting of soils for drainage. However, if only Class 2W and 3W soils are considered appropriate for drainage, then almost 50 percent of drain lengths miss these soils. Naturally, drains must often traverse well drained soils in order to provide outlet for the targeted lands, however, about half of the length of the average drain cuts through soils which have a low potential for benefit.

Of the two approaches, the first is considered to more accurately assess the ability of the drainage program to target appropriate lands for drainage for the following reason. A drain basin, by definition, contains all those lands which are ultimately drained by a common watercourse or drain. Thus, construction of a

drain would provide outlet drainage for all lands within the drain basin, not simply those lands immediately adjacent to the drain. Additional lateral surface and/or sub-surface drainage is usually required within the basin to achieve the maximum benefits of the drain (Found et al., 1974). These additions can extend the ultimate benefit to agriculture through most or all of the basin.

5.2 Wetlands Affected by the Program

Wetlands are known to form a significant element of the natural resources of many areas of the province, including eastern Ontario. They possess many natural functions and values, as noted above. The loss of wetland areas has been significant in the past. Of the seven counties in eastern Ontario which lie completely off the Precambrian Shield, all have lost more than 50 percent of their pre-settlement wetlands (Snell, 1982). The pressures on these areas continues today, and it is agricultural land drainage which causes the greatest and most widespread impact on the wetlands of southern Ontario including those of the study area of eastern Ontario (Bardecki, 1984a).

5.2.1 Possible Impacts on Wetlands

In general, three components of wetlands sustain impacts from agricultural drainage. The natural vegetation may be destroyed or altered as a result of clearing, or by changes in the water regime. This latter factor will be influenced by the type of wetland, and by the abruptness of any changes in the water regime. Wildlife habitat may be destroyed or altered through the loss of ponded water, loss of food plants or shelter, or loss of other specific wildlife needs (Whitney, et al., 1972). The hydrological values of wetlands may be destroyed or altered by the reduction or elimination of possible water storage and detention functions, and by the loss of water quality functions.

Wetlands are affected by drainage both directly and indirectly. Wetlands sustain direct damage from drains being constructed through them. A swath of vegetation is cleared to allow construction of the drain and the spreading of excavated material (Day, et al., 1976). Depending on the type and size of wetland, surface water may be drained away destroying or drastically altering the wetland. Effects would likely be serious in those wetlands with porous substrata. On the other hand, in a case study of a hardwood swamp in Brant County, a four and a half foot deep drain was found to have little effect on the water table beyond 46 meters, although the importance of the swamp as a water storage area in the spring was probably reduced (Found, et al., 1974).

The total length of the 64 drains under study that pass through wetlands is 15,400 metres or 6.1 percent of the total drain length (Table 6). However, some impacts have already occurred for those drains undergoing improvements/deepening (10,850 metres). Therefore, the length of new drains constructed through wetlands (4,550 metres; 1.8 percent of the total drain length) is of more concern. Despite this low percentage, the incremental wetland losses viewed over many years may be significant.

Wetlands located within drain basins are also more likely to be cleared in the future and drained using additional lateral surface drains and sub-surface tile drainage. As

agriculture intensifies in a region, pressure to drain remaining wetlands increases (Bardecki, 1984a). In addition, the construction of drains near wetlands in areas of sandy, porous soils may lower the water table in these wetlands. This would be less likely to occur in areas where clay or organic soils predominate. From the point of view of these indirect effects, the future prospects of any wetlands located within drain basins may be of concern.

The total area of wetlands located within the 64 drain basins surveyed is about 4,000 hectares. This is 11.8 percent of the total basin area (Table 5). By assuming that the area of wetlands within the 64 drain basins is representative of the wetland area within the 252 drain basins of the entire program, then 16,000 hectares, or about 10 percent of the total wetland area of the 45 townships in which the drains occur, could be directly or indirectly affected by the drainage program. This estimate takes on more significance when considering that the program has only been in operation since 1979.

5.2.2 The Occurrence of Wetlands in Eastern Ontario and in the Drain Basins

As a result of the corresponding low percentages of wetlands found in the 64 drain basins surveyed and throughout much of eastern Ontario, the drainage program appears to be neither avoiding nor targeting wetlands.

From an agricultural point of view, some wetlands that contain good agricultural soils, might be more valuable for growing food than for any natural values they may possess. With this in mind, the loss of wetlands comprising Class 2 and 3 soils might be considered a suitable trade-off to agriculture, assuming all natural values are known and have been assessed as of minor significance on a local and larger regional scale. The total area of Class 2 and 3 mineral soil wetlands is 1,178 hectares or 29.4 percent of the total wetland area surveyed in the 64 drain basins studied (Table 5). This leaves 2,827 hectares or 70.6 percent of the total wetland area that is classed as Class 4 through 7 and organic soils. These latter wetlands are likely to have very limited, if any, value to agriculture and, therefore, should, in most cases, be protected to preserve their intrinsic natural values as wetlands.

The majority (47) of the 64 drains surveyed have basins consisting of less than 10 percent wetlands (Figure 2). Of greater concern are the other 17 drains with higher percentages of wetlands in their basins. One drain basin (Lionel Rozon 81-207) consisted of over 40 percent wetland composed entirely of organic soils; no class 2W or 3W soils, either cleared or uncleared,occurred in any part of this basin. This suggests a lack of concern for wetlands without demonstrated concomitant benefits to be expected from agriculture, either from the wetland or from the rest of the basin.

The relatively low percentages of wetlands involved in the 64 drains surveyed may appear to be of limited significance. However, the problem of incremental losses of wetlands is of concern. Over a larger area, the loss of many small wetlands may have a cumulative effect on the hydrology of the area and on wildlife populations. Over a longer time, a much larger percentage of wetlands may be lost with significant cumulative effects. It appears that the current drainage program has

not attempted to deal with these problems.

Agricultural land drainage is generally expanding in eastern Ontario (Bardecki, 1984a). Those wetlands on the edge of the current drainage activity and currently under little pressure, will be subject to increased pressure for drainage with subsequent wetland losses to be expected.

5.3 Conformity to the Federal Policy on Land Use

The Municipal Outlet Drainage Program, as part of the Eastern Ontario Subsidiary Agreement, is in part a federal program, where federal monies help to subsidize the drainage of agricultural land. The Federal Policy on Land Use was released in 1981, two years after the beginning of the Municipal Outlet Drainage Program. The following section examines, in retrospect, how well the drainage program conforms to the new Federal Policy. The discussion may assist in determining what, if any, changes are required for any future drainage program to conform to the Policy requirements.

The Federal Policy on Land Use is a policy to guide federal policies and programs as they affect land use. The basis and goal of this Policy is "the wise use and sound management of the nation's land resources." It recognizes that land provides food, among other commodities, and is "an essential element in the control of pollution and the maintenance of productive ecosystems." One of the Policy's guiding principles relevant to the drainage program is that a "widely understood, comprehensive and current appreciation of land, its characteristics and use, is fundamental to sound land-use decisions by Canadians and their governments." A relevant policy statement is that the federal government will cooperate with the provinces and support provincial programs which help to achieve the goal of the Policy. In addition, a policy statement is included to the effect that for all significant land-related projects for which federal funds are provided, the Environmental Assessment and Review Process or a provincial equivalent will be applied. Finally, a relevant land-use guideline states that "the impact of policies and programs on watersheds, aquifers, recharge and storage areas, and other lands critical to the quality and quantity of the nation's water supply will be considered; and that appropriate action will be taken to ensure their protection."

Federal subsidization of agricultural land drainage in eastern Ontario is directed towards achieving "the wise use and sound management" of eastern Ontario's agricultural lands. However, the program's apparent lack of concern over the targeting of those lands most appropriate for drainage does not correspond with application of a "widely understood, comprehensive and current appreciation" of the land resource and its characteristics, such as its agricultural capability and its ability to benefit from drainage. Adoption of a system of prioritization for drainage in conjunction with a more systematic use of existing data on the land resource would bring the program into greater compatibility with the Federal Policy.

Considering the constraints within which the Drainage Petition Review Committee works, it does address wetland issues on a drain by drain basis. However, the drainage program's

apparent inability to deal with incremental losses of wetlands in eastern Ontario and the resultant cumulative effects resulting from these losses, and the lack of assessment of wetlands on a regional scale, point to a partial failure to apply a "widely understood, comprehensive and current appreciation" of the wetland resource. A mechanism, such as a class environmental assessment, is required to assess the effects of incremental loss on the wildlife, and the water quality and quantity of the whole region in order to allow better conformity with the Federal Policy. Also within the existing DPRC rules, wetlands cannot be protected where warranted by refusal of drain applications.

With respect to the policy statement on environmental assessment requirements, under somewhat different circumstances the provisions of the Ontario Drainage Act for environmental appraisals, and any assessments requested by the DPRC, would conform to the Federal Policy. However, under the Ontario Drainage Act, proponents of a drain are not required to provide any assessment of possible environmental impacts of a project unless requested. If an assessment is requested either by the DPRC or other agencies, the costs must be paid by those requesting the assessment (contrary to all other environmental legislation in Ontario). The experience with one drain showed the full Environmental Appraisal to be very costly. The result is that it has been left to the DPRC members to identify environmental concerns; however, they are constrained by limited time and resources. No class environmental assessment or screening procedure has been developed for agricultural land drainage. When the DPRC suspects a problem, its only remaining option is to place conditions on the drain approval to alleviate the concern. This approach can lead to an extended exchange with the engineer, which is expensive and time consuming for all parties. Drain refusal, the "No Go" option, is not available. All these considerations leave some doubt as to whether the drainage program actually conforms to the Federal Policy. An environmental assessment of the whole Municipal Outlet Drainage Program in eastern Ontario may be more appropriate to ensure conformance with the Federal Policy.

5.4 Benefit-Cost Analysis of the Activities of the Municipal Outlet Drainage Program

The Federal Policy on Land Use advocates the "wise use and sound management of the nation's land resources". Co-operative federal/provincial programs are supported if they are "operating in the national interest". This section applies these statements to the Municipal Outlet Drainage Program. It is assumed that it is sound management and in the national interest that federal funds be applied to projects for which the benefits outweigh the costs.

A definitive benefit-cost analysis of the drainage program would require a detailed inventory for each drain of a great number of on-farm factors including any increased farm profits, specific benefits to management in time, and labour savings as well as the consideration of those costs prerequisite to benefits (e.g. tile drain installation). It would also have to encompass the broader, long-term economic and environmental benefits and costs to society as a whole. Found, et al. (1974) analysed the on-farm portion of these benefits and costs, by farmer interview, in several areas of southern Ontario including

the area of eastern Ontario. They found many drains in eastern Ontario to have benefit-cost ratios below 1.0. For the Municipal Outlet Drainage Program, neither benefits nor costs have had time to fully occur. A complete assessment would require future monitoring.

At this stage only a very approximate appraisal is possible. A generous benefit to cost balance of those costs and benefits internal to agricultural production can be roughly estimated. This would reflect the situation of an ideal, high benefit and a minimum cost. Drains for which their minimum cost exceeds their ideal benefit likely could not reach a benefit-cost ratio of 1.0 even following a full assessment. To the contrary, some drains where ideal benefits do exceed minimal costs as indicated by this generous analysis, would fall below a benefit-cost ratio of 1.0 under actual conditions. This approach, therefore, will tend to err on the side of supporting the Drainage Program. Somewhat more realistic approximations with reduced benefits and a slightly greater range of costs are also presented.

5.4.1 The Ideal Net Benefit

The Municipal Outlet Drainage Program, as part of the Eastern Ontario Subsidiary Agreement, was designed to raise eastern Ontario farmers' incomes closer to those of the more prosperous farmers in southwestern Ontario. In 1980, the difference in average net income per improved hectare between nine counties in southwestern Ontario and six non-Shield counties of eastern Ontario was $52.04 (Table 10). To bring farmers in the better agricultural counties in eastern Ontario up to the same level as those of the southwestern region, one would need to almost double the average net income per hectare. Some of this difference in net farm income may be attributed to the contrasting levels in agricultural land drainage between the two areas, however, it would be overly optimistic to assume that increasing the level of drainage in eastern Ontario could, alone, bring the level of net farm income up to that achieved in the southwestern part of the province.

Agricultural land drainage can show benefit in specific circumstances. Hence, a specific level of benefit calculated from drainage studies in Ontario was sought. The task proved difficult because, in general, studies which have been conducted in Ontario to determine the change in net farm income resulting from drainage have used incorrect yield data due to the failure to adjust for annual precipitation differences (van Vuuren and Jorjani, 1983). Differences in yield between drained and undrained land depend on a number of factors, including the annual pattern of precipitation. As a result, reliance on yield differences from one or from a few successive years is inappropriate.

In one of the few attempts anywhere to deal with the influence of variable weather over a period of time on yield increases to be expected from drainage, van Vuuren and Jorjani (1983) have estimated the average annual yield increase in corn to be expected from drainage for soils at the Elora research station of the University of Guelph in southwestern Ontario. Their work is based on experimental data from a ten year period. These data were regressed against the precipitation levels at crucial planting and growing periods. The resulting coefficients were then employed to estimate the yield increases over a 67 year period, using the annual precipitation levels

TABLE 10

DIFFERENCE IN NET FARM INCOME BETWEEN

EASTERN AND SOUTHWESTERN ONTARIO

	A Number of Farm Tax Filers (1980)	B Average Net Farm Income $(1980)	C Total Net Farm Income (1980) $ (A X B)	D Number Improved Hectares (1981)	E Net Farm Income Per Improved Hectare $ (C - D)
Southwestern Ontario District**			157,141,845	1,421,525	110.63*
Eastern Ontario***					
Dundas	1,370	3,239	4,437,430	60,311	73.58
Glengarry	1,210	2,744	3,320,240	58,791	56.48
Grenville	890	645	574,050	32,100	17.88
Prescott	1,160	4,190	4,860,400	70,474	68.97
Russell	910	2,947	2,681,770	37,881	70.79
Stormont	950	1,999	1,899,050	43,798	43.36
TOTAL AVERAGE			17,772,940	303,355	58.59*

* The difference in Average Benefit per hectare is $110.63 - $58.59 = $52.04 per hectare per year in 1980.

** Southwestern Ontario District includes the counties of Brant, Elgin, Essex, Haldimand-Norfolk, Lambton, Middlesex, Niagara and Oxford. Hamilton-Wentworth is omitted due to the strong urban influence on average net farm income.

*** Ottawa-Carleton is omitted from the Eastern Ontario district due to the strong urban influence on average net farm income.

prevalent during this time. The annual net increase in yield attributed to drainage was found to be 790 kg per ha. This converts to a net annual benefit of $71 per hectare (1982 dollars). A conservative view was taken of costs. No figure was included for the installation of tile drains or for the construction or maintenance of outlet drains.

The value of $71 per hectare is adopted here as a measure of the ideal net benefit to be realized from drainage improvements alone. This figure was adopted because it is based on the actual results of a study which (1) is located near eastern Ontario, (2) used corn, the highest valued field crop[6], (3) covers a long time span, (4) accounts for variable patterns of precipitation, and (5) takes a view of costs exclusive of drainage.

In applying the ideal net benefit to individual drains, it is assumed that they each respond in the same manner. For drains which might in fact respond less than this ideal amount, the benefit is obviously over-estimated. For those which might respond above that level, the benefit is under-estimated. The estimated value represents the benefit from increases in crop yeild for corn; drainage may also allow for changes in crop type but, corn represents a particularly high value crop. Many changes in crop type will be to crops which produce less net benefit than here attributed to drainage; in addition, changes in crop type necessitate increased costs due to changes in farm operation, these will negatively affect the net benefit.

The net benefit used in the analysis is "ideal" since it assumes: a) the possibility that productivity in eastern Ontario could reach complete equality with southwestern Ontaro, a circumstance dismissed as impossibly optimistic by Found, et al. (1974); b) that all lands that are drained will be for the production of corn; and c) that all current disparity in net benefit can be attributed solely to drainage. In reality, many other factors such as climate, soils, facilities, and markets affect farmers' incomes as well; indeed, several aspects besides drainage are addressed under the EOSA agreement. It is, therefore, felt that the benefit in few, if any, drains in eastern Ontario could exceed this ideal.

The Treasury Board of Canada (1976) recommends the use of a social discount rate of 10 percent. This is a real rate, not a nominal one, implying that prices are held constant. However, this value has been criticized as being too high[7]. Some argue that a more appropriate measure for this discount rate is one net of any inflationary component. As a result, this study presents a parallel analysis using rates of 10, 7 and 4 percent.

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[6] The capability to grow corn was cited on most petition drain applications (Form 1) as "the expected change to agriculture" that would be derived from drain installations.

[7] Studies on the benefit-cost analysis of drainage projects have used rates of 4 percent (van Vuuren and Jorjani, 1983); 7 and 4 percent (Brooks, 1971); 6, 8 and 10 percent (Found et al., 1974); and 3, 5 and 7 percent (Coleman et al., 1983).

A generous estimate of drain life is 20 years (Found et al., 1974)[8]. It is assumed that over the 20 years, no other changes to income per hectare would be attributable to drainage. The ideal benefit in 1982 dollars (the net present value) over the 20 year life span of the drain amounts to $604 per hectare, given the Treasury Board's social discount rate of 10 percent per annum; to $752 at a rate of 7 percent; and $964 at the 4 percent discount rate.

5.4.2 Minimum Cost

Costs required to attain full benefits from municipal outlet drainage include:

1) those costs quoted by the engineering reports which include costs of construction, costs of the engineer, and costs of allowances for farm losses from construction (for example, for lost or damaged crops, land or fences). Hereafter, these costs are referred to as the engineering costs;

2) the costs of the installation of tile drains and lateral drains for which many main drains are intended as the outlet and which are often required before sizeable benefits accrue;

3) the costs of machinery, facilities and farm inputs to change the farm operation to that most benefited by drainage. These costs may even exceed the costs of the installation of tile drainage (Ontario Select Committee on Land Drainage, 1974);

4) maintenance costs; and

5) environmental costs and other costs external to the farm operation.

Environmental costs would include any adverse effects on wetlands. Also, eastern Ontario drains often suffer bank erosion which lowers their life; this not only increases maintenance costs but also potentially affects downstream aquatic life. McNeely Engineering Ltd. (1983) in a contract to DPRC suggests appropriate erosion control measures to reduce long term costs. Some of these measures are rarely included in current engineering methods; their inclusion would increase the construction costs of many drains beyond that of those assessed in this section.

For purposes of this analysis, the absolute minimum cost is considered to be that quoted by the engineering report (i.e the engineering costs alone). The engineering costs are intital costs expended before the stream of benefits begins and are, therefore, not subject to discounting. Naturally, limiting consideration to the engineering costs has the effect of substantially reducing the apparent cost of the drain construction.

5.4.3 Analysis of the 64 Municipal Drains Sampled

Initially, in this analysis the benefits derived from the sample drains are calculated

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[8] Found et al., (1974) consider a figure of 5 to 20 years for the life of a drain to be accurate; they cite an example in eastern Ontario of a minimum life for a drain as 5 years with more normal lifetimes extending to 20 years. Brooks (1971) working in eastern Ontario uses a project life of 20 years for drains on in clay soils and 12 years for drains on sands and silts. Coleman et al. (1983) use a figure of 25 years for the planning horizon for the construction of a municipal drain on Wolfe Island, however, they consider additional costs for maintenance to occur every 20 years.

for the entire area of each drainage basin. This assumes that the entire drainage basin will receive benefit from the drainage scheme; not only present arable land, but also all pasture, and all uncleared land no matter how poor the capability of the soil. The drain cost per hectare is compared to the ideal net benefit per hectare (i.e. $604 at 10 percent, $752 at 7 percent, and $964 at 4 percent). While the benefit was calculated on the basis of improved land under the crop at the University of Guelph, spreading the benefit over the whole basin applies benefit to unimproved land as well; therefore, this procedure further exaggerates the benefits.

Even, if all soils within the drainage basin produced such benefits in terms of increased agricultural production and income, the engineering costs (the absolute minimum costs) exceed the ideal average benefit per hectare of $604 (calculated at 10 percent) in 19 of the 64 municipal drians sampled (29.7 percent); they exceed the benefit calculated at 7 percent ($752) in 14 of the drains (21.9 percent); and they even xceed the benefits at a 4 percent discount rate in 8 of the drains (12.5 prcent [Table 11; Alternative A]).

As noted above, the assumptions underlying this analysis are overly optomistic or unrealistic in terms of:

1) an exaggeration of the land area from which the benefit can be derived;

2) an optimistic and likely unrealistic estimate of the level of benefit to be expected per hectare in eastern Ontario, and

3) the disregarding of many cost factors in the construction and maintenance of the drains so that only the intitial engineering costs are considered.

Assumptions for each of these factors will be relaxed independently.

First, the assumption regarding benefits derived from municipal drainage can be relaxed. It can be assumed that only 75 percent, rather than all, of the potential benefits from increased productivity can be realized in eastern Ontario due to the generally poorer climatic, economic and market conditions. Not all the differences in the agricultural viability between southwestern Ontario (Elora Research Station) and eastern Ontario could be attributable to municipal drainage improvements. Certainly, there are numerous problems in the agricultural sector in eastern Ontario. On that basis, at the 10 percent discount rate, 24 of the 64 drains (37.5 percent) have engineering costs alone tha. exceed benefits; at 7 percent, 20 drains (i.e. 31.3 percent) have engineering costs that exceed their benefits; and at 4 percent, still 15 drains (23.4 percent) have costs exceeding benefits (Table 11; Alternative B).

Second, independent of the previous assumption about the potential productivity in eastern Ontario, additional costs incurred in deriving benefits from drainage can be included. Often tile and lateral drains in fields are required before benefit of the municipal drains can be realized. While these on-farm drains are already in place in some farm areas, many municipal drains were justified on the basis of providing an outlet for future tile drainage of fields. The preceding benefit-cost comparisons assumed that there were no costs associated with the realization

TABLE 11

BENEFIT-COST ANALYSIS OF MUNICIPAL DRAINS:
ALTERNATIVE ESTIMATES FOR SAMPLE OF 64 DRAINS

Alternative	Benefit Assumption	Cost Assumption	Area Benefitting	Discount Rate	Drains for Which Costs Exceed Benefits: Number	Percent
A	net benefit equal to SW Ontario	engineering costs alone	entire basin	10%	19	29.7%
				7%	14	21.9%
				4%	8	12.5%
B	net benefit equal to 75% of SW Ontario	engineering costs alone	entire basin	10%	24	37.5%
				7%	20	31.3%
				4%	15	23.4%
C	net benefit equal to SW Ontario	engineering costs and tiling costs for 25% of basin	entire basin	10%	22	34.4%
				7%	21	32.8%
				4%	15	23.4%
D	net benefit equal to 75% of SW Ontario	engineering costs and tiling costs for 25% of basin	entire basin	10%	41	64.1%
				7%	31	48.4%
				4%	22	34.4%
E	net benefit equal to SW Ontario	engineering costs alone	limitation W, organic and imperfectly drained soils	10%	27	42.2%
				7%	25	39.1%
				4%	16	25.0%
F	net benefit equal to SW Ontario	engineering costs alone	Class 2W and 3W soils	10%	42	65.6%
				7%	38	59.4%
				4%	31	48.4%
G	net benefit equal to 75% of SW Ontario	engineering costs alone	limitation W, organic and imperfectly drained soils	10%	34	53.1%
				7%	28	43.8%
				4%	25	39.1%
H	net benefit equal to 75% of SW Ontario	engineering costs alone	Class 2W and 3W soils	10%	51	79.7%
				7%	46	71.9%
				4%	39	60.9%
I	net benefit equal to SW Ontario	engineering costs and tiling costs for 25% of basin	limitation W, organic and imperfectly drained soils	10%	32	50.0%
				7%	29	45.3%
				4%	25	39.1%
J	net benefit equal to SW Ontario	engineering costs and tiling costs for 25% of basin	Class 2W and 3W soils	10%	48	75.0%
				7%	46	71.9%
				4%	38	59.4%
K	net benefit equal to 75% of SW Ontario	engineering costs and tiling costs for 25% of basin	limitation W, organic and imperfectly drained soils	10%	55	85.9%
				7%	45	70.3%
				4%	32	50.0%
L	net benefit equal to 75% of SW Ontario	engineering costs and tiling costs for 25% of basin	Class 2W and 3W soils	10%	61	95.3%
				7%	58	90.6%
				4%	48	75.0%

of full benefit from the outlet drains through the construction and installatin of on-farm drains. Considering the need for the provision of on-farm drainage in the drain basins under study, as indicated in the original applications, it is reasonable to add a proportion of the tile and lateral drainage cost to the benefit-cost calculations.

Brooks (1971) noted that outlet drains produce beneficial responses on a significant scale only if tile drainage is installed. Found et al. (1974) confirmed this observation. Outlet drains may be of benefit, but this is dependent on the local hydrology. Only in unusual circumstances can outlet alone provide benefit-cost ratios in excess of 1.0 (Found et al., 1974).

The cost of tile in the Kingston, Ontario area has been quoted at $865 to $990 per hectare ($350-$400 per acre) (R. Irwin, pers. comm. 1983), and by the Prescott, Ontario office of the Ministry of Agriculture and Food as $865 per hectare ($350 per acre). A figure of $900 per hectare is used in this analysis. This tile installation charge is considered to be intital cost that is required before benefits can be derived and, therefore, is not discounted.

It is assumed that only 25 percent of the basin area need be tiled in order to realize the total benefit potential of the outlet drain construction. Thus, $900 x 25% = $225 is added to the average cost per hectare for drainage while benefits remain as before. Of the 64 drains studied, 22 possess benefit-cost ratios of less than 1.0 under these assumptions at a discount rate of 10 percent; 21 are under 1.0 at the 7 percent rate; and 15 at 4 percent (Table 11; Alternative C).

If increasing the cost (by $225 per hectare) resulting from tile drainage installation is combined with the assumptin that only 75 percent of the potential productivity based on corn can be relized, the results are clear. At a discount rate of 10 percent, 41 (i.e. 64.1 percent) of the drains have benefits lower than costs; at 7 percent, 31 (i.e. 48.4 prcent) have benefits lower than costs; and at the 4 percent discount rate, still 22 (i.e. 34.4 percent) of the drains do not provide enough benefit to cover costs (Table 11; Alternative D).

It is important to stress that all the calculations above are based on the assumption that all lands in the drainage basin will receive equal benefit from the land drainage.

Now, consider the land area within the drainage basins. Clearly, all soils within the drainage basins are not capable of generating an increased level of farm production because of drainage. A more realistic approach would be to focus only on those soils that under a broad assumption might possibly benefit from drainage, namely, all cleared imperfectly drained soils, very poorly drained and poorly drained soils, as well as organic soils; these together constitute 59.5% of the area in the drain basins studied. An even more conservative, but certainly realistic, approach would be to assume that only Class 2W and 3W soils (which form 28.5% of the area of the study basins) could derive agricultural benefits from improved outlet drainage. As is apparent, if the same ideal average benefits, as calculated at the various discount rates, were applied to either of these considerably more limited areas of the drainage basins, then far more of the 64 municipal drains sampled would have

engineering costs that exceed benefits. For example, there are 13 municipal drains with no Class 2W or 3W soils in the drainage basins, and thus no benefits whatsoever under the most conservative approach.

It is not necessary to go through a comprehensive outline of all combinations of assumptions, these are presented in Table 11. It is significant, however, that in taking into account what is still a reasonably generous set of assumptions, one finds that a very high proportion of drainage schemes do not return enough benefit to cover costs. For example, consider Alternative L (Table 11). The basic assumptions for this alternative are as follows:

a) only those areas with Class 2W and 3W soils will return benefit; these being the only soils limited by wetness that have the potential for reasonably achieving net benefit from the drainage;

b) the only costs included are the engineering costs and the costs of tiling 25 percent of the drain basin (since Class 2W and 3W soils constitute 28.5 percent of the drain basins, this effectively means that these soils will be tiled). Generally, the installation of tile drains is necessary to achieve benefit. Despite the presence of other costs, as outlined above, these additional costs are ignored;

c) the general productivity of the climate, soils and market conditions in eastern Ontario allows the realization of 75 percent of the net benefit from drainage that was reported from experimental plots growing corn at the University of Guelph in southwestern Ontario;

d) the drain life is 20 years, and

e) the discount rate of 10 percent as suggested by the Treasury Board (1976) is used, however, alternative rates of 7 and 4 percent are presented.

Given these still liberal assumptions, at 10 percent discount rate, 61 drains (i.e. 95.3 percent) are not cost effective; at 7 percent, 58 drains (i.e. 90.6 percent) are likewise; and even at 4 percent, the discount rate creating the most optomistic view of the future trajectory of the benefit stream, 48 drains (i.e. 75 percent of drains) have costs that exceed the expected benefits.

As yet in the discussion, no farm operation conversion costs, drain maintenance costs or environmental costs have been considered. Their inclusion would dim still further the prospects of finding municipal drains for which benefits outweigh costs.

It is cautioned that the above discussion uses overview numbers and assumptions in lieu of as yet unavailable drain-specific data on future benefits or tile costs. Broad trends are determined rather than a complete benefit-cost analysis for specific drains. It is important to note, however, that an effort has been made to err on the side of the outlet drainage program by use of reasonable but optimistic estimates of the benefits from drainage while providing a very limited scope for the inclusion of those costs associated with the projects.

6. SUMMARY AND CONCLUSIONS

Consideration of the results and analyses of a survey of 64 drains approved by the Drainage Petitition Review Committee, under the Municipal Outlet Drainage Program of the Eastern Ontario Subsidiary Agreement, has led to the following conclusions.

1) The Municipal Outlet Drainage Program has not been effective in targeting the appropriate lands for drainage. Generally, the soils that are appropriate, in that they are likely to receive benefit from outlet drainage, consist of Class 2W and 3W soils, as rated under the CLI Soil Capability for Agriculture system. Within the 64 drain basins surveyed, 28.5 percent of the total basin area was comprised of Class 2W and 3W soils, no greater a proportion than would be expected by a random selection of areas in eastern Ontario. Assuming that the survey sample was a representative one-quarter of all 252 drains in the program, then 40,000 hectares of class 2W and 3W soils were drained by the 252 drains. About 390,000 hectares of Class 2W and 3W soils occur in the fourteen counties of eastern Ontario eligible for drain assistance. While acknowledging that some some of this land is currently drained, more effective targeting of appropriate lands for drainage could be possible.

2) In retrospect, the drainage program did not entirely comply with the Federal Policy on Land Use. It was found that the drainage program did not possess the mechanisms to make use of a complete, comprehensive and widely understood knowledge of the land resource of eastern Ontario as it related to soils and agricultural capability. Approvals were made irrespective of the land resource characteristics. In addition, the DPRC has virtually no control over the costs of the drain, resulting in little direct accountability by the engineering firm.

The DPRC had neither a mechanism to analyze, nor one to make use of comprehensive knowledge of the wetland resource in terms of the effects of incremental losses over space and time to both agriculture and other resource sectors. The drainage program also did not entirely satisfy the provision of requiring some form of environmental assessment process; the high costs of producing environmental appraisals coupled with DPRC constraints of limited time and resources, effectively prevented adequate access by the DPRC to environmental information. In order to guide decision-makers in the assessment of drainage proposals, some form of general assessment is needed of the overall effect of the drainage program on the environment of eastern Ontario and of the impacts of individual projects of concern.

3) A rough estimate of drain benefits suggests that a significant number of the surveyed drains are unlikely to generate future benefits equal to the costs of the drain. The additional cost of tile drainage, often needed before full benefits can be realized, will make still more drains poor investments. Federal participation in these drains would seem not to comply with the Federal Policy on Land Use. These findings are perhaps not

surprising since no mechanism exists in the current review procedure to estimate or even priorize benefits of drains.

The benefit-cost analysis performed in this paper is internal to agricultural production. A more comprehensive evaluation must recognize the presence of both external costs imposed by the drain construction (e.g. loss of wildlife habitat, adverse affects on downstream water quality, change in character of affected non-agricultural properties), and the potential for wider societal benefits (e.g. drainage near to roadways increases their bearing capacity, and near housing may provide for improved septic tank disposal field performance, and there may also be multiplier effects associated with the expenditure for drainage).

4) Drainage is a necessity for the realization of the full potential of crop production in many areas in eastern Ontario, but investments in the provision of such projects must be cost-effective and in fairness, should be related more closely to those who will benefit directly. Given the presence of subsidies for the construction of outlet drainage works, and no effective evaluative mechanism to target lands most likely to benefit from drainage, drainage of lands with low agricultural capability will occur. The individual farmer does not directly bear a large share of the financial cost (12.5 percent of the total in the drains under study), but does obtain most directly the benefits of any increased productivity. Drainage of land is undertaken, instigated by individual farmers or by drainage engineers, on lands that would not be drained if individuals had to pay a proportion of the costs more in balance with the share of benefits that accrue to them. The nature of the petition procedure for the initiation of drains is such that it has been suggested that given a local goodwill, many farmers will support a drain petition even though they may realize no personal benefit, thus further encouraging the construction of drains which on closer examination are not viable.

5) This study has attempted to quantify the total amount of wetlands possibly affected by drainage. No attempt was made to quantify effects. For this, the Canadian Wildlife Service, Ontario Region, is currently undertaking more detailed studies of specific wetlands in eastern Ontario and is involved in the federal-provincial wetland evaluation program underway thoughout southern Ontario. A comparable proportion of wetland area to total area occurs both within the 64 drain basins surveyed and within the 45 townships where most of the 252 drains occur, thus indicating that the drainage program has neither avoided nor targeted wetlands. Wetlands are an increasingly scarce resource. The 4,000 hectares of wetlands included in the 64 surveyed drain basins suggest that about 16,000 hectares of wetland lie within the 252 drains of this single five year program. This latter figure is about 10 percent of the total area of wetlands in the 45 townships represented by the 252 drains. While not all wetlands will be seriously affected, the extent of the potential impact raises the issue of possible incremental losses of wetlands

accumulating to a significant degree over a relatively short time. The possible cumulative effects are not being addressed by the existing drain-by-drain review mechanism.

Twenty-seven percent of the surveyed drain basins consisted of greater than 10 percent wetlands. The majority of these wetlands (about 70 percent) have low probable value in agriculture.

7. RECOMMENDATIONS

The following recommendations address some of the problems and inefficiencies encountered in the Municipal Outlet Drainage Program. Many of these recommendations have already been voiced by representatives of Environment Canada and others. It is anticipated that these recommendations will help to create a more cost effective and environmentally acceptable drainage program for the benefit of the eastern Ontario region while not significantly raising the costs.

1) Additional information should be made available to the DPRC along with Form 1, at the initial drain evaluation stage, in order to allow a more thorough and comprehensive evaluation. This would permit the early flagging of potential environmental problems and/or the clarification of whether the drain merits funding based on the amount of agricultural benefits to be derived. All of this would make more efficient use of DPRC's time. Additional information may include:

   a) a clear map locating the drain and showing lots, concessions, township, north arrow, scale and drain basin outline; aerial photography, if available, might be included;

   b) a copy of the county soils map and a corresponding 1:50,000 agricultural capability map showing the drain and its basin;

   c) information on what drainage facilities already exist;

   d) a broad estimate of the drain cost, provided by the engineer; otherwise, cautious use could be considered of average cost per metre figures, weighted by the number of road crossings, etc., to arrive at an approximation;

   e) a copy of the current wetlands map and/or topographic map showing the drain and its basin; and

   f) additional information provided on Form 1 concerning potential physical, biological and related economic problems; this could be provided by district offices of the Ontario Ministry of Natural Resources and local Conservation Authorities.

2) Terms of reference should be provided to engineers so that environmental problems such as sedimentation, downstream flooding, habitat loss and others are addressed in the engineering report.

3) A part-time technician, possibly located at the Kemptville office of the Ontario Ministry of Agriculture and Food, could ensure that DPRC members are provided with the above information for each drain application received.

4) Screening procedures and criteria for federal funding approval of drain applications should be adopted by the DPRC for use in its evaluation. The following points are offered for consideration:

   a) a mechanism is required for balancing agricultural values against other natural resource values when an

evaluation is made. Some wetlands are a valid trade-off for agricultural benefits while others are more valuable to the eastern Ontario region as natural wetlands. More complete information is required on individual wetlands and the overall wetland resources of eastern Ontario before informed decisions are made. Program extension or future programs should await completion of the federal-provincial wetland evaluation mapping program for eastern Ontario. If this proves too lengthy, provision should be made to allow wetlands within future proposed drain basins where federal grants are considered to be assessed between the time of the petition and the approval process. Also, program extension or future programs should await an assessment of the overall wetland resources of the region and the environmental, social and economic effects of their incremental loss;

b) the "no approval" option must be available to the DPRC in order for it to effectively act on screening procedures and criteria for drain applications;

c) drain applications must be compatible with the Watershed Management Plans of local Conservation Authorities; program extension or future programs should await the completion of these plans;

d) for approval, it must be demonstrated that the area of soils in need of outlet drainage within the drain basin (especially 2W and 3W soils) is sufficient to warrant construction in light of the cost involved;

e) if lands within a drain basin are unsuitable for drainage, then the drain should not be approved regardless of costs; if lands are suitable and costs are reasonable, then the drain should be considered for approval; however, if lands are suitable but the costs on a per hectare basis are noticeably high, then the costs should be carefully weighed against the probable benefits;

g) more time and money should be available for the DPRC to study large, significant drains which are generally expensive and have the potential for greater environmental problems and costs.

5) Criteria for distinguishing situations requiring extra environmental or benefit information from those where concerns are minimal should be adopted by the DPRC. This would allow more efficient use of the DPRC's time. The following points are offered for consideration:

a) copies of Agricultural Capability maps, county soils maps, and current wetland maps with drain basins and drains clearly indicated, would provide a quick assessment of potential land use conflicts, erosion problems, suitability of soils for drainage and the relative amounts and size of wetlands affected;

b) information on the compatibility of proposed drains to Watershed Management Plans of local Conservation Authorities would allow a quick assessment of potential problems;

c) a proposed drain considered to be relatively expensive should generally indicate that more information is required on the probable benefits expected to agriculture.

6) An environmental assessment of the Municipal Outlet Drainage Program in eastern Ontario should be conducted prior to any extension of the program or commencement of a new one. This assessment, among other things, would determine any potential cumulative effects of agricultural land drainage and wetland loss on the natural environment of eastern Ontario.

7) A benefit-cost study of the Municipal Outlet Drainage Program in eastern Ontario should be conducted prior to any extension of the program or commencement of a new one. Included in its terms of reference should be development of indicators that approval bodies could use to recognize proposals for which benefits are likely to outweigh costs, and vice versa.

8) The approval process for federal subsidization of the drainage program should be removed from the restrictions of the Ontario Drainage Act. The Act preempts Federal legislation and among other problems, places the costs of an environmental assessment for a drain project on those requesting information rather than on the proponent.

9) Federal funding should be conditional on a system of calling for tenders to select an engineering firm to design proposed drains. The current situation provides no safe-guards or checks on the costs of drains and results in little accountability by the engineering firms. They are virtually given a carte-blanche once the initial approval has been made.

10) Consideration should be given to studying the net benefit to farmers and the conformance to the Federal Policy on Land Use if federal assistance to agriculture were based on a policy of helping farmers to adjust their operations to fit the land resource rather than to adjust the land resource to fit the operation. Governments have many alternatives for increasing food production and farm incomes other than subsidizing drainage (e.g. income stabilization, interest rate subsidy, and productivity incentive programs); likewise, individual farmers have various options in dealing with management of wet areas through changing cropping and cultural practices. Both of these avenues are worth exploring.

11) In any extension of the present program, or in any future federally funded drainage program, the federal department with the environmental mandate should be included in the review process.

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APPENDIX: FORM 1

MUNICIPAL OUTLET DRAINAGE PROGRAM

UNDER THE

CANADA-ONTARIO EASTERN ONTARIO SUBSIDIARY AGREEMENT

NOTICE OF INTENT TO CONSTRUCT

1. APPLICANT:

Municipality _____ County _____

Name of Clerk _____ Telephone _____

Mailing Address _____ Postal Code _____

2. PROJECT:

Name of Drain _____ No. of Petitioners Involved _____

Estimate Number of Agricultural Acres Involved _____ Total Acres in the Drainage Basin: _____

Lots Involved _____ Concessions Involved: _____

Date Petition Presented to Council _____ Engineer's Name: _____

Is Engineer's Report Available? _____

3. Has the drain previously received an ARDA grant towards its construction? YES __ NO __

If Yes, list: Name of Drain: _____

Date of Completion: _____

Total Cost of Drain: $_____ Amount of Grant Rec'd $_____

Has any by-law been passed on this drain: YES _____ NO _____

4. Is the proposed drain located in a Conservation Authority? YES _____ NO _____

Name of Authority: _____

5. It is understood that one condition of the approval of a grant under this program will be the direct seeding of the ditch bank of this municipal drain within 24 hours of construction or as soon thereafter as conditions permit. Also that the drainage area as defined on the original petition does not increase by more than 25%.

_____

Clerk

6. Include a map, sketch, etc. from proposed drainage area and channel. Please include six copies of the drainage petition and forward to the local agricultural office of the Ontario Ministry of Agriculture and Food. Also, if Engineer's Report is available please forward 5 copies to the address on the back of this form.

(OVER)

SUPPLEMENTARY INFORMATION TO BE PROVIDED BY
LOCAL AGRICULTURAL STAFF

1. Indicate the major soil types in the proposed drainage area: _____

_____

2. For the drainage area of the above drain, please indicate the percentage of farms in the following categories:

1. Monoculture (specify)	_____%	4. Hay	_____%
2. Corn System	_____%	5. Pasture	_____%
3. Mixed	_____%	6. Grazing	_____%

3. Comment on the need for the drain and indicate whether it is major improvements, maintenance or new construction: _____

_____

_____

_____

4. Expected changes to agriculture, including crops and drainage: _____

_____

_____

_____

O.M.A.F. STAFF

When completed please forward to the Chairman, Drainage Petitition Review Committee, O.M.A.F., 315 Raglan Street South, Renfrew Ontario K7V 1R6

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